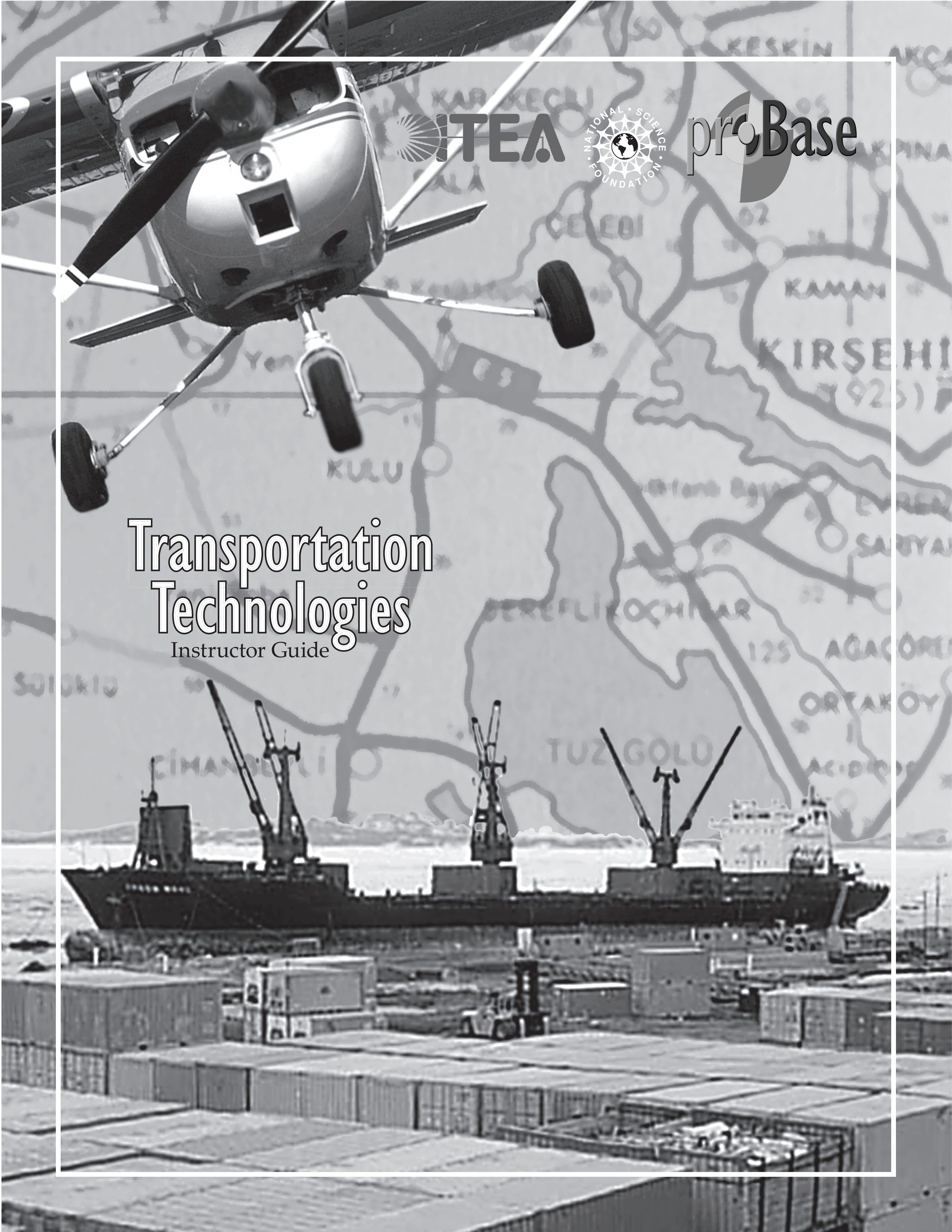

ITEA NATIONAL SCIENCE FOUNDATION proBase

Transportation Technologies

Instructor Guide

Acknowledgments

Engaging Technology

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Learning Unit Overview

Learning Unit Purpose

As our nation's economy, society at large, and environment are increasingly influenced by technological innovations it is imperative that our educational system keep pace and is able to prepare students for highly technical careers. This Project ProBase Learning Unit, titled *Transportation Technologies,* is designed to help prepare high school students who plan to go on to community college technical education or university-level engineering programs.

This unit is one of eight Learning Units developed by Project ProBase to address the critical need for upper high school technology education curriculum. The Project ProBase Learning Units utilize hands-on, problem-based activities to introduce fundamental technology concepts related to each context area standard identified in *Standards for Technological Literacy: Content for the Study of Technology* published by the International Technology Education Association.

You may be interested in the other Learning Units developed by Project ProBase:	
• *Agriculture and Related Biotechnologies*	• *Construction Technologies*
• *Entertainment and Recreation Technologies*	• *Energy and Power Technologies*
• *Information and Communication Technologies*	• *Manufacturing Technologies*
• *Medical Technologies*	• *Transportation Technologies*

Constructivist-based Teaching and Learning

Each Learning Unit is driven by authentic open-ended problems offering multiple opportunities for students to construct knowledge about the world around them. Constructivism is a learning theory based on the belief that humans learn best when they construct their own knowledge based on their experiences.

One goal of the ProBase Learning Units is to provide a variety of authentic, contextually-based experiences that students can use to construct accurate knowledge and develop appropriate skills across the contexts of technology. Constructivist learning is accomplished by providing experiences and opportunities that encourage students to construct accurate knowledge and understanding. Each Learning Unit considers the student as a creator of knowledge and assumes that the teacher will facilitate this acquisition of knowledge. This is contrary to the notion that teachers are "dispensers" of knowledge and requires a paradigm shift for some.

As facilitators of learning, ProBase instructors will need to prepare for class in a slightly different way. Students will still need materials and equipment as they engage in activities.

Instructors should review all of the learning cycles in advance so that they know what materials and equipment to gather, as well as what types of demonstrations must be provided. Another important reason for reviewing the learning cycles is to begin thinking about appropriate questions to ask the students. Sample questions are provided in the *Reflection* phase of each learning cycle. However, the instructor may want to go beyond these questions to probe student thinking to find out the technological perspectives students bring to the class. The instructor should ask questions that challenge student thinking and present new ideas that help students create conceptual change.

Connecting Standards for Technological Literacy: Content for the Study of Technology

Enduring Understandings

Each Learning Unit developed by Project ProBase was developed to address three to four enduring understandings derived from *Standards for Technological Literacy: Content for the Study of Technology* (STL) published by the International Technology Education Association (2000/2002). According to Wiggins and McTighe in *Understanding by Design* (1998, p. 10), an enduring understanding "refers to the big ideas, the important understandings, that we want students to 'get inside of' and retain after they've forgotten many of the details."

In an effort to distill the enduring understandings from STL, each standard was filtered through the following questions:

- Does the standard represent a big idea having enduring value beyond the classroom?
- Does the standard reside at the heart of the discipline?
- Does the standard require uncoverage of abstract and often misunderstood ideas?
- Does the standard offer potential for engaging students?

This process yielded nine enduring understandings. For a complete list of enduring understandings along with corresponding essential questions, see appendix page AA.

Students will understand:

1. That technological progression is driven by a number of factors, including individual creativity, product and systems innovations, and human wants and needs.

2. That technological development for the solution of a problem in one context can spinoff for use in a variety of often unrelated applications.

3. That technological change can be positive and/or negative and can have intended and/or unforeseen social, cultural, and environmental consequences.

4. How technological systems work, the components of those systems, and how they fit into the larger technological, economic, and social systems.

5. The compelling and controversial issues associated with the acquisition, development, use, and disposal of resources.

6. That the complexities of technological design involve trade-offs among competing constraints and requirements, including engineering, economic, political, social, and environmental considerations.

7. That technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.

8. How technological assessment is used to determine the benefits, limitations, and risks associated with existing and proposed technologies.

9. How to utilize a variety of simple and complex technologies.

Essential Questions

Each enduring understanding must be "unpacked" to be meaningful for learning and instruction. Therefore, each enduring understanding has several essential questions associated with it. The essential questions are addressed through the learning cycles.

Bridge Competencies

In addition to focusing on the enduring understandings derived from STL, each Learning Unit helps to address a set of Bridge Competencies developed in conjunction with a consortium of central Illinois community college partners. Representatives from this consortium reviewed each Learning Unit to identify where the Bridge Competencies were being addressed. Each Learning Unit contains a matrix that reflects which Bridge Competencies are addressed in that specific Learning Unit.

Learning Unit Framework

Each Learning Unit developed by Project ProBase follows a similar format in an effort to be consistent and true to a constructivist-based curriculum.

Preliminary Challenge

Students will be introduced to the Learning Unit through a hands-on activity designed to pique their interest and begin to establish a focus for the Learning Unit.

Primary Challenge

Next, the students are introduced to a robust *Primary Challenge,* which is far too complex to be solved at this point in the unit. Students will be asked to reflect on the knowledge and skills needed to reach a plausible solution to this challenge. This instructor-led discussion happens just before the students are led through a series of four-phase learning cycles designed to develop the knowledge and skills necessary to successfully complete the *Primary Challenge*. Time is provided throughout the nine-week Learning Unit to actually work on a solution to the *Primary Challenge*.

Four-phase Learning Cycles

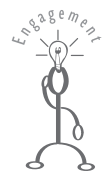
In order to develop plausible solutions for the *Primary Challenge*, students must gain accurate knowledge and appropriate skills throughout each Learning Unit. The learning experiences found in the Project ProBase curriculum are developed using a four-phase learning cycle.

Phase one: Exploration

During this phase of each learning cycle, students will be exploring selected concepts while engaged in hands-on activities. The explorations are done individually, as well as in teams. The goal of the *Exploration* phase is to have students construct accurate knowledge about each concept under investigation.

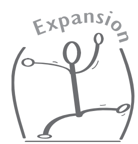
Phase two: Reflection

The *Reflection* phase of the learning cycle offers an opportunity for students to think about what they know about the concepts under investigation. Their reflections are recorded in an Inventor's Logbook that can be used to check their understanding. This phase of the learning cycle also provides an opportunity for the instructor to clear up lingering misconceptions and to be sure that all students are ready to move on.



Phase three: Engagement

The *Engagement* phase of the learning cycle allows the student to apply the knowledge and skills that they are constructing. This phase reinforces their understanding of the important concepts. The activities that students are engaged in are as authentic as possible and are often team activities.



Phase four: Expansion

This phase of the learning cycle is where students can extend their new understandings to new situations. Students should select one of the activities from the several that are suggested. Some of the *Expansion* activities are designed to be done as individuals as homework and some are team activities.

Student and Instructor Roles During Each Phase of the Learning Cycle

Learning Cycle Phase	Student's Role	Instructor's Role
Exploration	• Interacts with materials and equipment • Collects, records, and analyzes data • Designs solutions • Investigates concepts	• Asks questions • Gathers materials • Oversees safety and skills instruction • Encourages Inventor's Logbook entries
Reflection	• Answers questions in Inventor's Logbook • Forms generalizations • Compares team data • Participates in discussions	• Questions students • Leads class discussions • Corrects misconceptions • Facilitates class data sets
Engagement	• Applies concepts, principles, theories • Designs and builds solutions • Solves problems	• Supplies materials • Keeps students on task • Corrects lingering misconceptions • Assures safe practice
Expansion	• Extends concepts to different contexts • Researches • Records journal entries in Inventor's Logbook	• Provides appropriate resources • Questions students to ensure connections are made to broader context

Preparing for the Challenge

A goal of the Project ProBase curriculum is to have students work toward the *Primary Challenge* throughout each Learning Unit. Therefore, at the end of each learning cycle students are asked to reflect on the *Primary Challenge*. In many cases, the student is provided time to work on the solution to the *Primary Challenge* for a day or two between learning cycles.

Inventor's Logbook

Each Learning Unit developed by Project ProBase makes use of an Inventor's Logbook. An icon like the one above is placed throughout the Learning Unit whenever students are expected to answer specific questions, record data, or write down their observations. The specific requirements for this logbook are left for you to determine.

The Inventor's Logbook entries will also be used to check and assess student progress toward the concepts that each learning cycle is focused on. The rubrics provided at the end of each learning cycle contain an Inventor's Logbook element where the specific concepts are identified. This will encourage your students to make regular entries in their student text and provide dynamic documentation of their progress.

Student Assessment

Student assessment is an important component in the ProBase curriculum. The Instructor's Guide provides several optional rubrics to use for formative and summative student evaluation. The Inventor's Logbook is designed to be a formative assessment of student progress. The Instructor's Guide contains a rubric for assessing each student's Inventor's Logbook. In addition, each *Primary Challenge* has a rubric for summative evaluation.

The *Engagement* phase of each learning cycle affords a unique opportunity to assess student progress. Therefore, a rubric unique to the *Engagement* phase is provided as often as possible.

Rubrics have been inserted in the Instructor's Guide and the Student's Guide for assessing a student's contribution to teamwork and daily engagement/preparation.

Materials and Equipment

The Project ProBase curriculum is designed to be taught in a general technology laboratory facility. Each learning cycle details the equipment and materials needed for that specific activity. Each Learning Unit also includes a compiled list of all the equipment and materials needed for the unit in the front of the Instructor's Guide. By design and as much as possible, the equipment and materials used for the activities are easy to find, over-the-counter materials. Where appropriate and necessary, specific vendors have been identified and their contact information has been provided.

Learning Cycle One:
1e. What are the fundamental processes/principles used to develop new technologies?

Learning Cycle Two:
4a. What are the systems and subsystems involved in the various contexts of technology?

Learning Cycle Four:
4b. What are the key elements of the various technological systems and what are the relationships between these systems?

Learning Cycle Four:
6b. What are the key factors that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems? (Micro Factors)

Learning Cycle Five:
7f. How can the establishment of relationships, controlling variables, categorizing techniques, and making inferences aid in the development of new technological designs?

Learning Cycles One, Three:
8a. How does a risk/benefit analysis aid the designer in addressing potential harmful effects prior to development?

Learning Cycles Two, Four, Five:
9b. How do technologies communicate with one another and provide information to humans?

Transportation Technologies Overview

Up to this point, we have been discussing the Project ProBase Learning Units in general terms. The following points will be specific to *Transportation Technologies*.

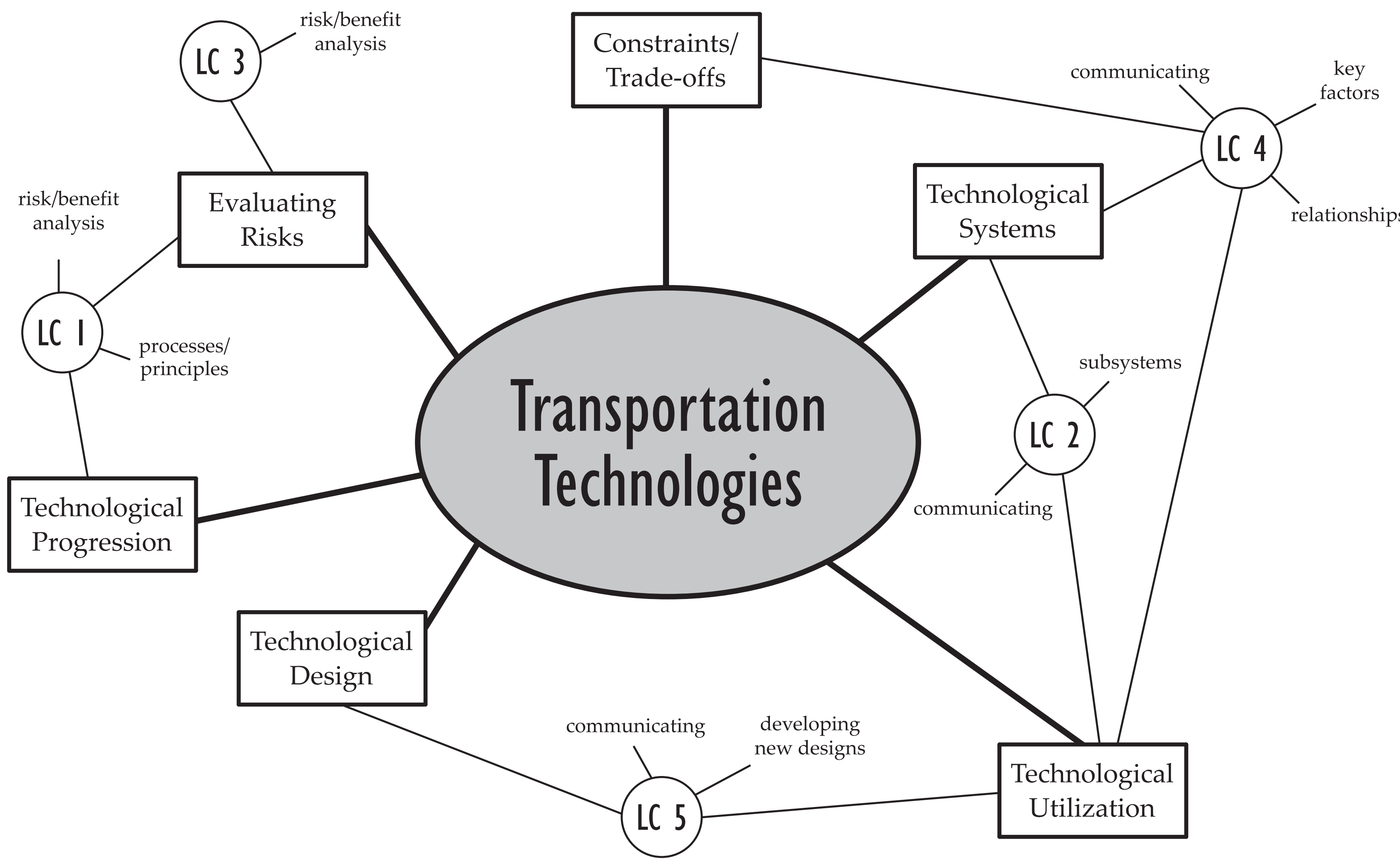
Enduring Understandings and Essential Questions

The *Transportation Technologies* Learning Unit focuses on five of the nine enduring understandings. As they complete *Transportation Technologies*, students will understand:

1. that **technological progression** is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.
4. how **technological systems** work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
6. that the complexities of technological design involve **trade-offs** among competing **constraints** and requirements, including engineering, economic, political, social, and environmental considerations.
7. that **technological design** is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.
8. how to **evaluate** the benefits, limitations, and risks associated with existing and proposed technologies.
9. how to **utilize** a variety of simple and complex technologies.

The essential questions addressed in each learning cycle will be correlated to the learning cycle objectives.

Transportation Technologies Learning Unit Concept Map



Transportation Technologies Learning Unit Equipment and Materials List

Learning Unit Consumables (based on a class size of 28 students)

Qty.	Item	Learning Cycle	Notes and Recommended Options
NA	Magazines	Preliminary	Have the students bring in magazines from home
7	Scissors	Preliminary	
NA	Adhesive	Preliminary	Glue, tape, etc.
112 sheets	Colored paper	Preliminary	16 sheets per team (4 each of 4 different colors)
	Used bicycles (and/or parts)	LC 1	Optional
	Wood slats	LC 1	Optional
	Nuts, bolts, and nails	LC 1	Optional
	Various other materials for *Engagement*	LC 1	
7	Photocopies of protractor	LC 2	Appendix
	Screws and washers	LC 2	
	1/4″ Plywood	LC 2	
	1/2″ PVC pipe	LC 2	
	Glue sticks	LC 2, 3, & 4	
5	48″ Clear plastic tubes	LC 3	Used to protect fluorescent lights; found at local hardware stores
50	Round magnets	LC 3	Strong; approximately 1″ diameter
7	Springs	LC 3	Loose tension; approximately 3″ x .75″
7	Golf tees	LC 3	
7	Medium balloons	LC 3	
27	Plastic drainpipes	LC 3	1.5" x 6"
27	#8 Rubber stoppers	LC 3	
27	#7 Rubber stoppers	LC 3	
7	Styrofoam blocks	LC 3	3" x 3" x 3"
7	Foam peanuts	LC 3	

Learning Unit Consumables cont'd

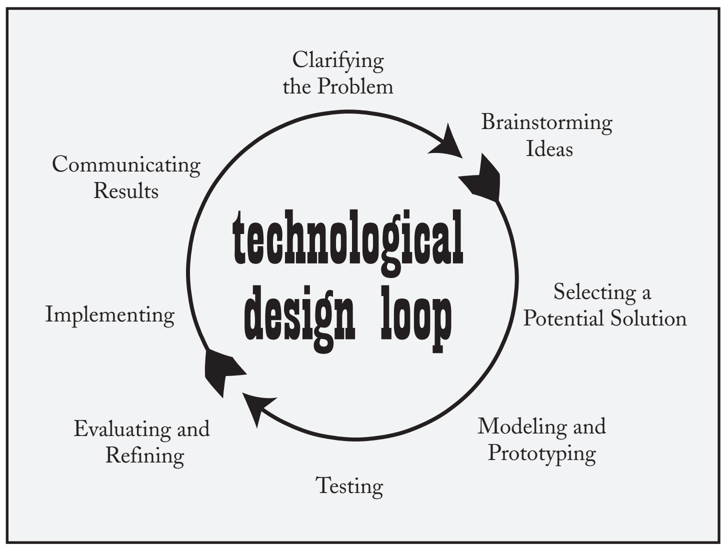
Qty.	Item	Learning Cycle	Notes and Recommended Options
70	Wood craft sticks	LC 3	
28	Straws	LC 3	
14	Eye hooks	LC 3	
7	12 oz. paper cups	LC 3	
7	Index cards	LC 3	
7	Wood blocks	LC 3	3" x 3" x 1"
14	Rubber bands	LC 3	
2 rolls	Masking tape	LC 3	
50 feet	String	LC 3	
1	Large gate hinge	LC 3	
50 feet	Nylon fishing line	LC 3	at least 50 lb. test
4	Eye screws	LC 3	
1	Lumber	LC 3	1" x 6" x 48"
14	Wooden tongue depressors	LC 4	
7	Paper hole punches	LC 4	
84	Brass paper fasteners	LC 4	
14	Pegboards with ⅛" or ¼" holes	LC 4	6" x 8"
	Various materials for solutions in *Engagement*	LC 4	
45'	½" PVC pipe	LC 5	
9	½" PVC T-connectors	LC 5	
NA	PVC glue	LC 5	
9	AA batteries	LC 5	
36"	⅛" Welding rod for wheel axles	LC 5	
9	¼" Eyescrews	LC 5	
	Various materials for solutions in *Engagement*	LC 5	
	Various materials for solutions (see student plans)	Primary Challenge	Used bicycles

Learning Unit Equipment cont'd

Qty.	Item	Learning Cycle	Notes and Recommended Options
3-4	Scissors	Preliminary	
	Band or scroll saw	LC 1	
	Hammers	LC 1, 2, and 3	
	Power drill and drill bits	LC 1, 2, and 3	
	Hot glue guns	LC 1, 2, and 3	
	Tape measures	LC 2	
	Laser measuring device	LC 2	Visible laser beam and a range of 60′
2	Small toy wagons	LC 3	
1	CO_2 firing pin set	LC 3	(Pitsco # 11341)
2	Hack saw	LC 5	
7	1000 gram weight	LC 5	(e.g. bucket of water or sand; stack of metal washers)
9	Gear Box and Motor Kits	LC 5	kits should provide multiple configurations
38	Wheels 1⅝" Diameter	LC 5	
38	Wheels 3" Diameter	LC 5	
9	AA Battery Holders	LC 5	
9	Slide Switches	LC 5	0.5A DC/3A AC
9	Spring Scales	LC 5	5 Newton capacity

THE ProBase DESIGN MODEL

As a constructivist, problem-based curriculum, the ProBase Learning Units offer a variety of opportunities for students to engage in design activities. The ProBase Learning Units have been developed for upper high school technology education students. It is assumed that students engaging in the ProBase curriculum possess some prerequisite knowledge and skills regarding engineering design. If students do not have previous experience in this area, it may be necessary to provide a brief introduction to design-based problem solving. It is suggested that you use the following design model adapted for the ProBase curriculum from *Standards for Technological Literacy* (International Technology Education Association, 2000/2002).



If you see a need to introduce the design-based problem solving process, it is suggested that you do so in a constructivist manner using a simple design problem. For example, you might have your students use the model presented above as they design a cover for a book or CD. You should attempt to use media beyond paper and pencil such as modeling clay, Styrofoam™, Balsa wood, or cardboard. Other simple design ideas include designing paper airplanes, a package for their favorite snack, a marketing flyer for a new product, an ergonomic handle for a shaving razor, or prototype cardboard seat or a model of other furniture pieces.

Transportation Technologies Unit Calendar

Week	Day 1	Day 2	Day 3	Day 4	Day 5
1	Course Introduction; Preliminary Challenge	Preliminary Challenge	Preliminary Challenge	Intro to Primary Challenge; Enduring Understandings	Learning Cycle 1 - *Exploration*
2	Learning Cycle 1 - *Exploration* *Reflection*	Learning Cycle 1 - *Engagement*	Learning Cycle 1 - *Engagement*	Learning Cycle 1 - *Engagement* Preparing for the Challenge	Learning Cycle 2 - *Exploration I* *Reflection*
3	Learning Cycle 2 - *Exploration II*	Learning Cycle 2 - *Exploration II* *Reflection*	Learning Cycle 2 - *Engagement*	Learning Cycle 2 - *Engagement*	Learning Cycle 2 - *Engagement* Preparing for the Challenge
4	Learning Cycle 3 - *Exploration I*	Learning Cycle 3 - *Exploration I* *Reflection*	Learning Cycle 3 - *Exploration II*	Learning Cycle 3 - *Exploration II* *Reflection*	Learning Cycle 3 - *Engagement*
5	Learning Cycle 3 - *Engagement*	Learning Cycle 3 - *Engagement* Preparing for the Challenge	Learning Cycle 4 - *Exploration I*	Learning Cycle 4 - *Exploration I* *Reflection*	Learning Cycle 4 - *Exploration II*
6	Learning Cycle 4 - *Exploration II* *Reflection*	Learning Cycle 4 - *Engagement*	Learning Cycle 4 - *Engagement*	Learning Cycle 4 - *Engagement* Preparing for the Challenge	Learning Cycle 5 - *Exploration I*
7	Learning Cycle 5 - *Exploration I* *Reflection*	Learning Cycle 5 - *Exploration II*	Learning Cycle 5 - *Exploration II* *Reflection*	Learning Cycle 5 - *Engagement*	Learning Cycle 5 - *Engagement*
8	Preparing for the Primary Challenge	Preparing for the Primary Challenge	Preparing for the Primary Challenge;	Primary Challenge	Primary Challenge
9	Primary Challenge	Primary Challenge	Primary Challenge	Presentations of the Primary Challenge	Presentations of the Primary Challenge

*For block scheduling, adjust the Unit Calander appropriately

Transportation Technologies

Table of Contents

Preliminary Challenge

Pieces of the Puzzle 5
Research Modes of Transportation

Primary Challenge

It's A-Drought Time 13
Design and Build a Vehicle to Transport Water

Learning Cycle One

The Right Fit 23
Exploration - Investigate *Primary Challenge* Client Nations
Engagement – Design and Build a Technologically Appropriate Device

Learning Cycle Two

Plotting the Course 35
Exploration I – Calculate Distance Using Mathematics
Exploration II – Construct a Transit
Engagement – Determine the Accuracy of Your Transit

Learning Cycle Three

Safety First 51
Exploration I – Research Vehicle Safety
Exploration II – Construct Suspension Systems
Engagement – Design, Test, and Analyze a Vehicle's Suspension System

Learning Cycle Four

Out of Control 73
Exploration I – Research Braking Systems
Exploration II – Manipulate Linkage Configurations
Engagement – Design and Build a Carriage System

Learning Cycle Five

Ready, Set, Go! 91
Exploration I – Conduct a Torque Experiment
Exploration II – Experiment with Gears and Gear Configurations
Engagement – Design and Build a Vehicle to Pull With the Greatest Force

Preliminary

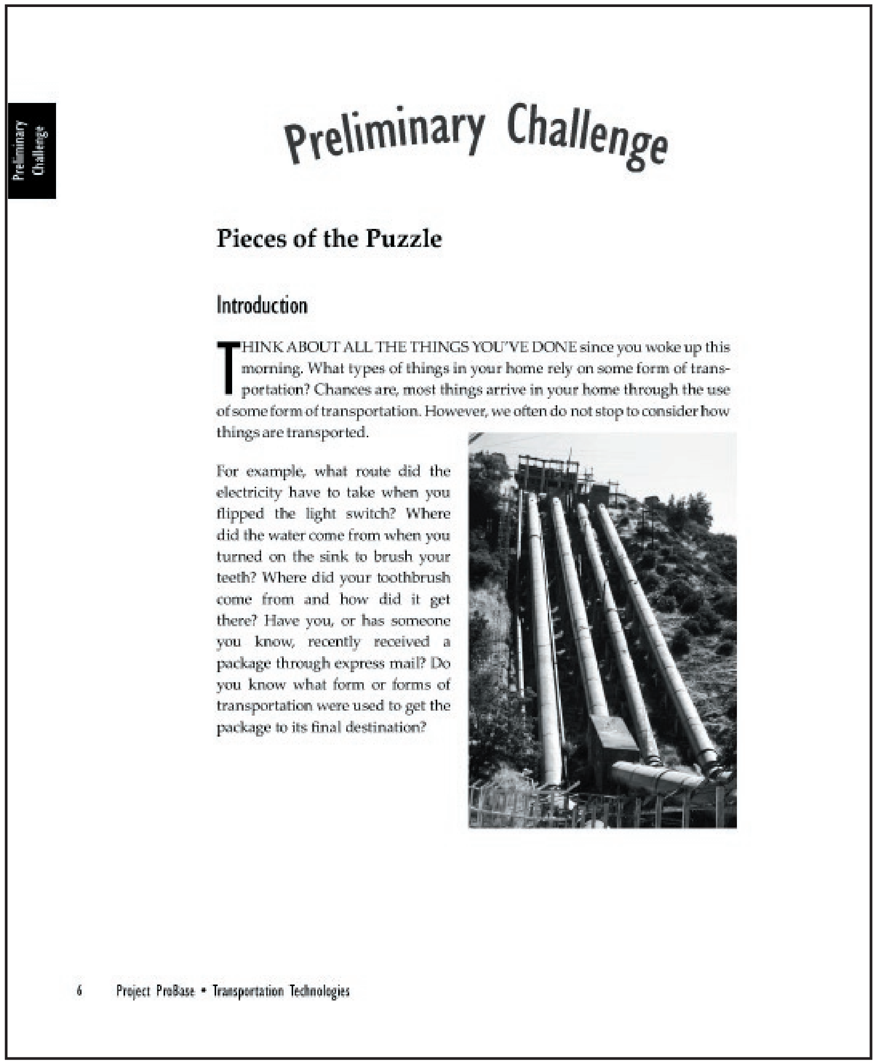
Preliminary and Primary Challenges

Primary

Pieces of the Puzzle

Introduction

The goal of the *Preliminary Challenge* is to get the students interested in learning about transportation technologies. It is designed to introduce the students to the four modes of transportation, which will be discussed following this introduction. Many students probably have the preconception that transportation involves getting into a car and driving. They probably do not consider that transportation can involve carrying any object, not just people, from one location to another and might sometimes include a stationary vehicle (such as a pipeline).



Preliminary Challenge

Preliminary Challenge

Pieces of the Puzzle

Introduction

THINK ABOUT ALL THE THINGS YOU'VE DONE since you woke up this morning. What types of things in your home rely on some form of transportation? Chances are, most things arrive in your home through the use of some form of transportation. However, we often do not stop to consider how things are transported.

For example, what route did the electricity have to take when you flipped the light switch? Where did the water come from when you turned on the sink to brush your teeth? Where did your toothbrush come from and how did it get there? Have you, or has someone you know, recently received a package through express mail? Do you know what form or forms of transportation were used to get the package to its final destination?

6 Project ProBase • Transportation Technologies

Defining the four modes of transportation (the students should come up with these on their own):

- Terrestrial - Transportation systems moving objects over land.
- Marine - Transportation systems moving objects on or through water.
- Atmospheric - Transportation systems moving objects through the air, within the Earth's atmosphere.
- Space - Transportation systems moving objects outside of the Earth's atmosphere.

Preliminary Challenge

Team work

Perhaps you walked to school, rode the bus, or drove your car. These forms of transportation seem more obvious to us as we see them on a regular basis. Let's work in teams while taking a closer look at the broad modes of transportation.

Throughout this Learning Unit, you will be working in teams. Research has shown that teams can be more effective than individuals at solving complex problems. However, effective teams are not easily formed. Team members must work to understand each other. As a team member, you should know where your team is going and help to set goals for the team. All members of your team should strive to develop an open communication system where everyone can contribute. Each team member needs to assume responsibility and should be assigned to part of the project. Be patient and listen to your teammates.

Pieces of the Puzzle 7

Key Concepts

Each Learning Unit is designed to facilitate several enduring understandings. The key concepts have been synthesized from the enduring understandings and essential questions and will focus the learning cycles in this Learning Unit. Each learning cycle is keyed to one or more of the following enduring understandings:

Students will understand:

1. that **technological progression** is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.

4. how **technological systems** work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
6. that the complexities of technological **design** involve trade-offs among competing **constraints** and requirements, including engineering, economic, political, social, and environmental considerations.
7. that **technological design** is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.
8. how to **evaluate** the benefits, limitations, and risks associated with existing and proposed technologies.
9. how to **utilize** a variety of simple and complex technologies.

Preliminary Challenge

Learning Unit Goal

The Learning Unit goal provides a target for the Transportation Learning Unit. As students complete this unit, they will be able to understand that:

Transportation is a controlled system that carries cargo from one location to another while protecting the cargo.

Equipment and Materials

Based on a class of 28 students:

Internet

Magazines (You could have the students bring in magazines from home.)

Scissors

Adhesive (glue, tape, etc.)

Colored Paper (16 sheets/group, 4 each of 4 different colors, a total of 112 sheets)

Facility Requirements

This activity can be conducted in any environment with ample space. When putting together the puzzle, the students will need a sizable (approximately 10′ x 10′) work area to put together their puzzle without interfering with other groups.

Estimated Number of 50-minute class periods: **4**

Suggested Daily Outline

Day One	Day Two
Introduction Puzzle work	Puzzle work cont'd.
Day Three	**Day Four**
Puzzle explanation *Reflection*	Introduction to the Primary Challenge

Preparing for the Preliminary Challenge

The goal of this Learning Unit is for the students to develop a working knowledge of the following concept:

To understand that transportation is a controlled system that carries cargo from one location to another while protecting the cargo.

Students should understand this statement in relation to the four modes of transportation.

Teaching Tips

It is suggested that you present this goal to the students before they begin working on their *Preliminary Challenge.* Although they are not expected to understand it in detail at this point, they need to become familiar with this material.

Throughout this Learning Unit, as well as other ProBase Learning Units, students will work in teams to accomplish tasks and solve problems. You may already encourage and require teamwork in some of your classes.

The main reasons for placing your students into teams is to help them better understand how and why team participation works, and for them to become more effective team members. Another purpose is to cause them to work together so that you can evaluate the teams and determine the best team configuration for the *Primary Challenge* work.

Studies show that teamwork:

- Makes a large task seem less daunting.
- Simulates and prepares students for a real-world work environment.
- Increases productivity.
- Allows students to get a different point of view on issues–each student brings something different to the work table.
- Increases knowledge–students learn from you, but they also learn effectively from their peers.

Teaching Tips

Add some of the ideas listed above to the student-generated list. Explain why teamwork is important and describe how teamwork will be essential when completing the activities in this Learning Unit.

Teamwork promotes behaviors that might not be present in a larger class setting. It provides opportunities for participation for those students who normally would not speak up. It gives everyone the opportunity to contribute. It also teaches responsibility by holding the students more accountable for their learning.

Some points are worth discussing with the students:

- Organization
- Inclusion, not exclusion
- Developing a plan of action

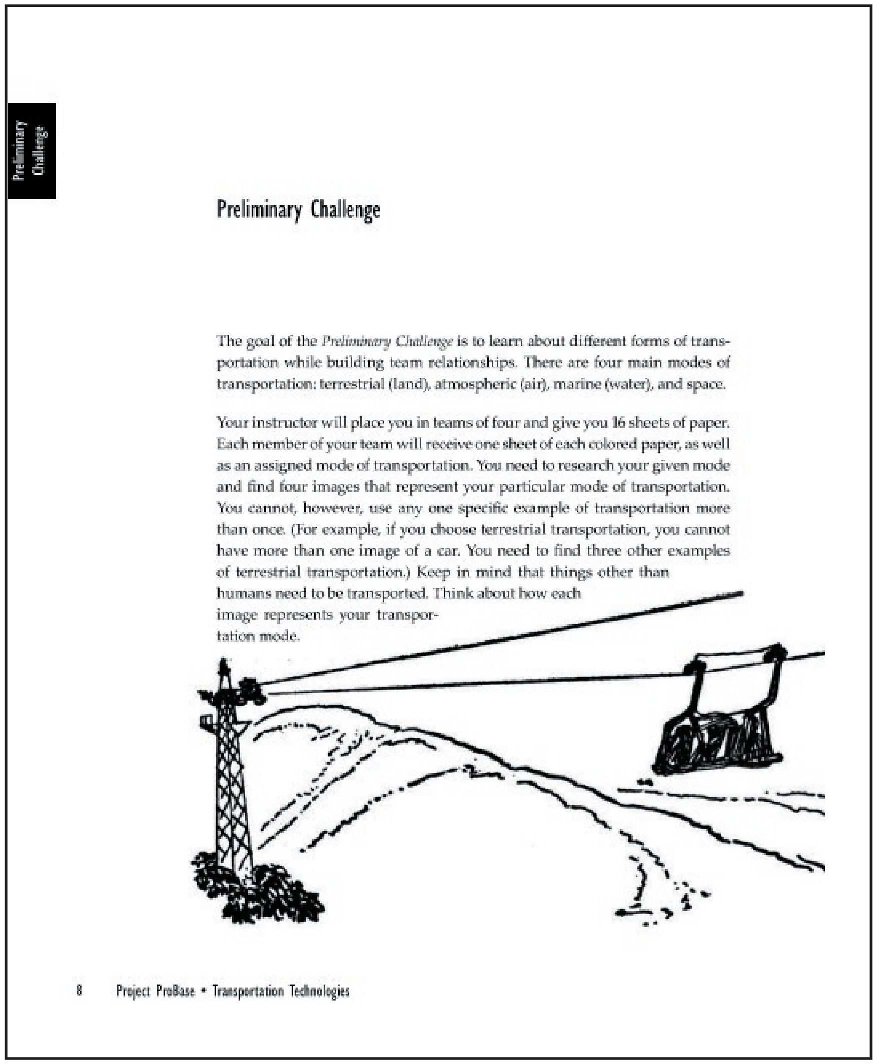
Preliminary Challenge

Place the students in groups of four and hand each student four sheets of each color of paper, (For example, one student receives a sheet each of yellow, green, blue and red.) Students should then research and find four images from their assigned mode of transportation.

As the students place their pieces together, remind them that:

- No two images from the same transportation modes can be in the same row or column.
- No two papers of the same color can be in the same row or column.

See example puzzle on the next page for a sample of the solution.



Preliminary Challenge

Preliminary Challenge

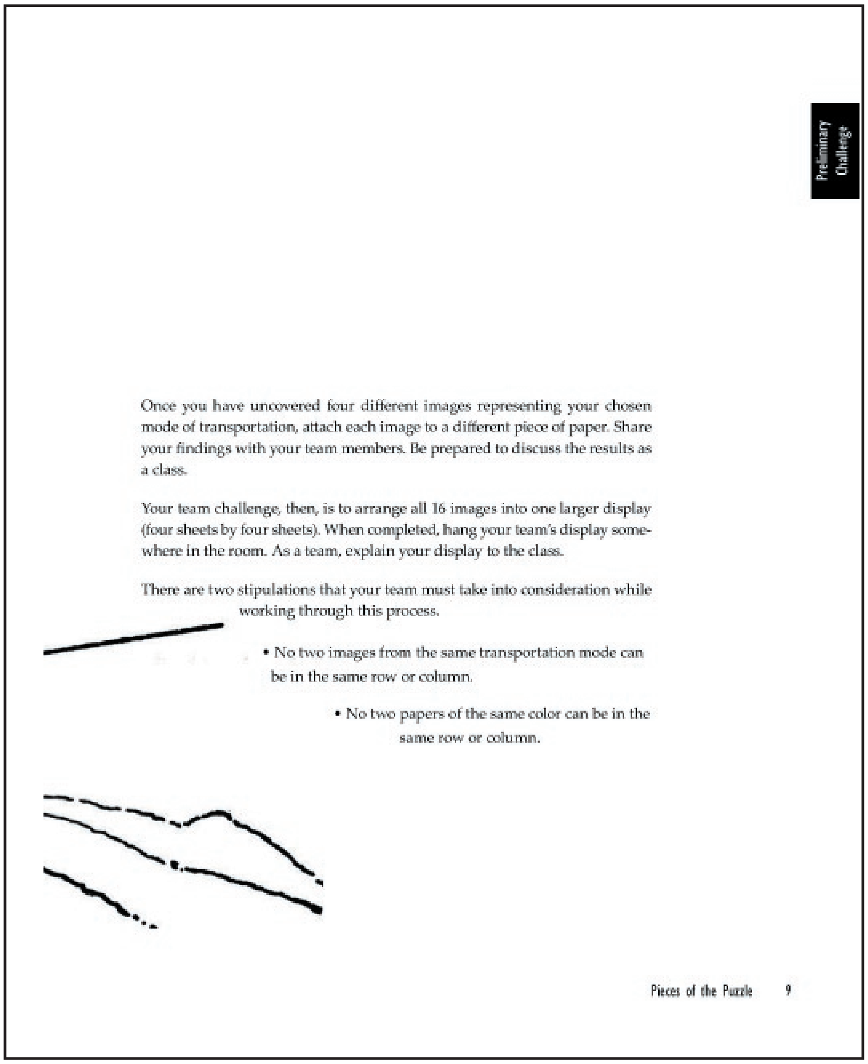
The goal of the *Preliminary Challenge* is to learn about different forms of transportation while building team relationships. There are four main modes of transportation: terrestrial (land), atmospheric (air), marine (water), and space.

Your instructor will place you in teams of four and give you 16 sheets of paper. Each member of your team will receive one sheet of each colored paper, as well as an assigned mode of transportation. You need to research your given mode and find four images that represent your particular mode of transportation. You cannot, however, use any one specific example of transportation more than once. (For example, if you choose terrestrial transportation, you cannot have more than one image of a car. You need to find three other examples of terrestrial transportation.) Keep in mind that things other than humans need to be transported. Think about how each image represents your transportation mode.

8 Project ProBase • Transportation Technologies

Teaching Tips

The images needed for this challenge can be found in any type of magazine or on the Internet. If time permits, you may suggest that the students bring in magazines on their own. Images need to be adhered, attached, or printed on the colored sheets of paper. If you have a scanner or Internet access, you should encourage your students to use digital images for this activity. Make sure that all pictures are attached to the paper in the same way (portrait or landscape).


Preliminary Challenge

Once you have uncovered four different images representing your chosen mode of transportation, attach each image to a different piece of paper. Share your findings with your team members. Be prepared to discuss the results as a class.

Your team challenge, then, is to arrange all 16 images into one larger display (four sheets by four sheets). When completed, hang your team's display somewhere in the room. As a team, explain your display to the class.

There are two stipulations that your team must take into consideration while working through this process.

- No two images from the same transportation mode can be in the same row or column.
- No two papers of the same color can be in the the same row or column.

Pieces of the Puzzle 9

T **red**	**M** **yellow**	**A** **green**	**S** **blue**
M **yellow**	**T** **red**	**S** **blue**	**A** **green**
A **green**	**S** **blue**	**T** **red**	**M** **yellow**
S **blue**	**A** **green**	**M** **yellow**	**T** **red**

Example puzzle solution

Preliminary Challenge key

T=terrestrial
M=marine
A=atmospheric
S=space
color name = paper color

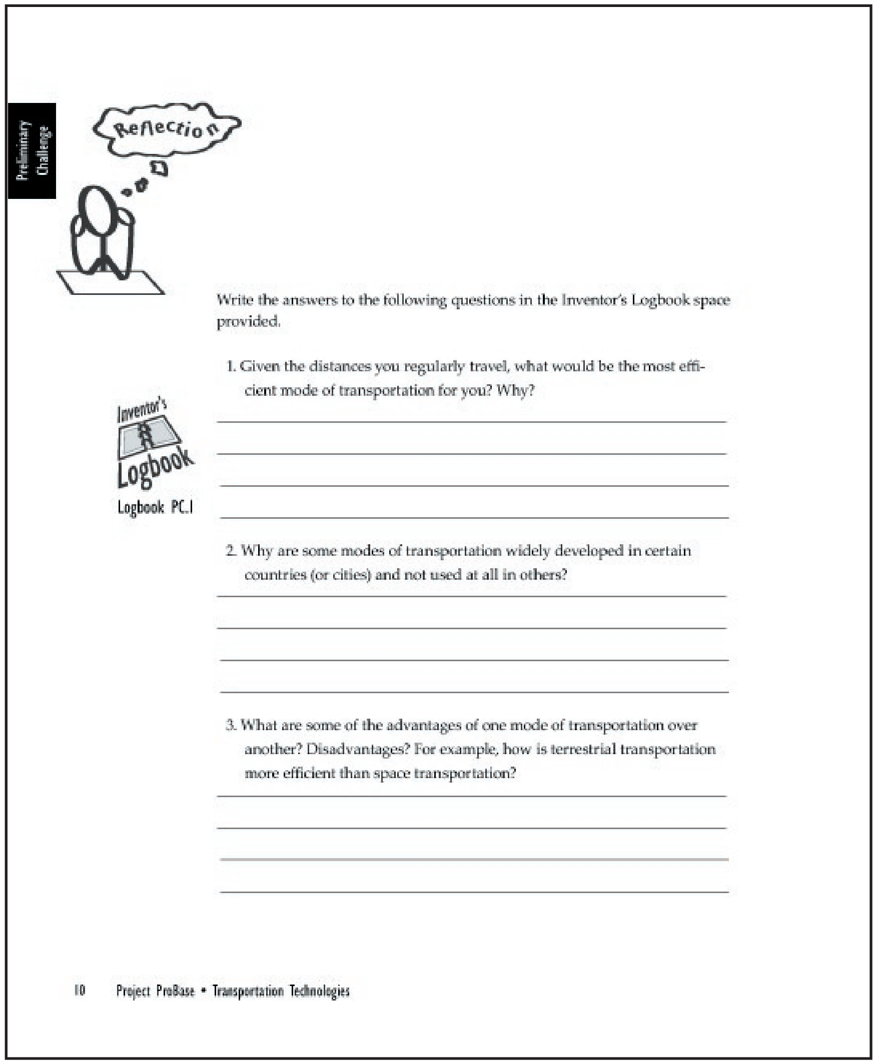
Reflection

Review and discuss the *Reflection* questions and the Inventor's Logbook entries. Students should answer *Reflection* questions in the text in the Inventor's Logbook spaces provided. Responses will vary depending on class discussion.

1. Given the distances you regularly travel, what would be the most efficient mode of transportation for you? Why?

2. Why are some modes of transportation widely developed in certain countries (or cities) and not in others?

3. What are some of the advantages of one mode over another? Disadvantages? For example, how is terrestrial transportation more efficient than space transportation?



Preliminary Challenge

Reflection

Inventor's Logbook

Logbook PC.1

Write the answers to the following questions in the Inventor's Logbook space provided.

1. Given the distances you regularly travel, what would be the most efficient mode of transportation for you? Why?

2. Why are some modes of transportation widely developed in certain countries (or cities) and not used at all in others?

3. What are some of the advantages of one mode of transportation over another? Disadvantages? For example, how is terrestrial transportation more efficient than space transportation?

10 Project ProBase • Transportation Technologies

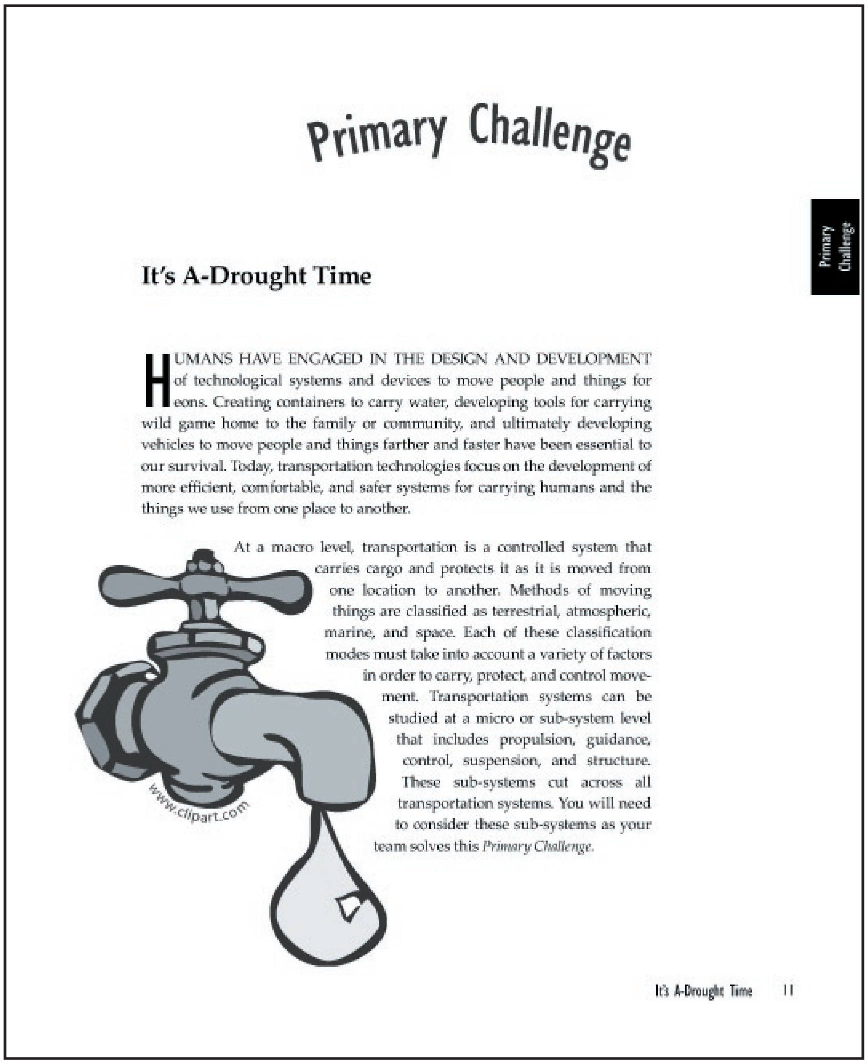
Facilitating Class Discussion

Once all of the puzzles have been put together, lead a class discussion on the different modes of transportation.

Teaching Tips

Groups should then explain their completed puzzle to the class. Some questions to think about as students present:

- Why did they choose a specific image?
- What were some of the challenges or difficulties that arose when completing the puzzle?
- How does a particular image represent a particular mode of transportation?



Primary Challenge

Primary Challenge

It's A-Drought Time

HUMANS HAVE ENGAGED IN THE DESIGN AND DEVELOPMENT of technological systems and devices to move people and things for eons. Creating containers to carry water, developing tools for carrying wild game home to the family or community, and ultimately developing vehicles to move people and things farther and faster have been essential to our survival. Today, transportation technologies focus on the development of more efficient, comfortable, and safer systems for carrying humans and the things we use from one place to another.

At a macro level, transportation is a controlled system that carries cargo and protects it as it is moved from one location to another. Methods of moving things are classified as terrestrial, atmospheric, marine, and space. Each of these classification modes must take into account a variety of factors in order to carry, protect, and control movement. Transportation systems can be studied at a micro or sub-system level that includes propulsion, guidance, control, suspension, and structure. These sub-systems cut across all transportation systems. You will need to consider these sub-systems as your team solves this *Primary Challenge*.

It's A-Drought Time 11

Teaching Tips

Since the *Primary Challenge* probably looks overwhelming to your students, you will need to reassure them at this point. It is a good idea to make sure expectations are clear. Let students know that they will be provided with the necessary information to be successful. You could show them the unit calendar, pointing out the days reserved for work on the *Primary Challenge*.

You should also hand out the *Primary Challenge* rubric to give the students a clearer idea of what they will need to do. It is important for you to read the entire *Primary Challenge* section and understand the constraints for the challenge before discussing it with your students.

Primary Challenge

It's A-Drought Time

Introduction

The *Primary Challenge* should be introduced immediately after students complete the *Preliminary Challenge* so they can begin to relate the concepts developed through the learning cycles to this challenge. You should address any questions about the *Primary Challenge* at this time.

Approximately two weeks are built into the schedule throughout this Learning Unit for students to work on the solution for the *Primary Challenge*.

Students will be asked to reflect on this challenge and work on parts of their solution at the end of each learning cycle in a section titled *Preparing for the Challenge*.

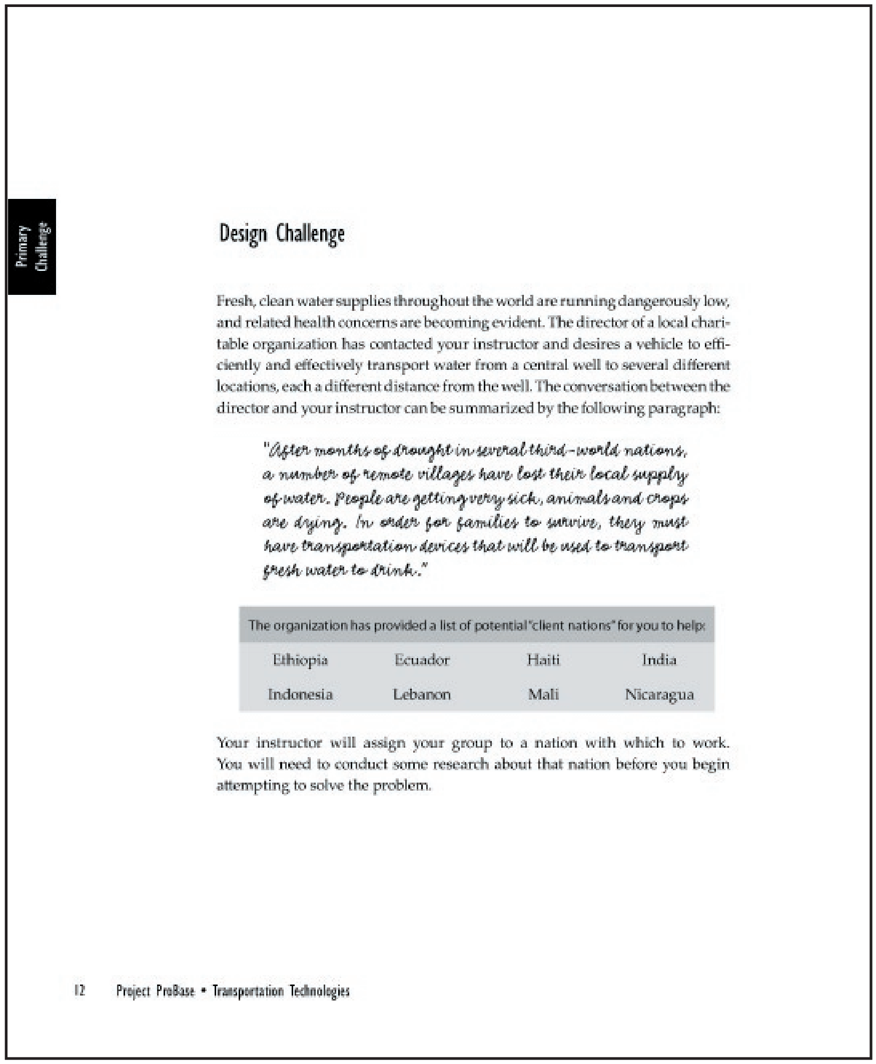
Primary Challenge

Preparing for the Primary Challenge

The *Primary Challenge* requires the students to design and fabricate a transportation system that can travel over the terrain found in a particular country to several specified destinations while protecting cargo (water).

The students' solutions must incorporate sub-systems for propulsion, guidance, structure, support, and control. There will be learning cycles related to each of these concepts throughout the Learning Unit.

Estimated Number of 50-minute class periods: **15** *(throughout the Learning Unit)*



Primary Challenge

Design Challenge

Fresh, clean water supplies throughout the world are running dangerously low, and related health concerns are becoming evident. The director of a local charitable organization has contacted your instructor and desires a vehicle to efficiently and effectively transport water from a central well to several different locations, each a different distance from the well. The conversation between the director and your instructor can be summarized by the following paragraph:

"After months of drought in several third-world nations, a number of remote villages have lost their local supply of water. People are getting very sick, animals and crops are dying. In order for families to survive, they must have transportation devices that will be used to transport fresh water to drink."

The organization has provided a list of potential "client nations" for you to help:			
Ethiopia	Ecuador	Haiti	India
Indonesia	Lebanon	Mali	Nicaragua

Your instructor will assign your group to a nation with which to work. You will need to conduct some research about that nation before you begin attempting to solve the problem.

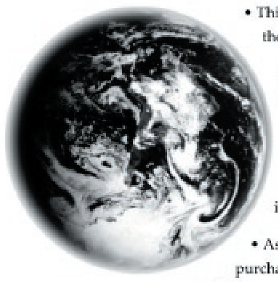
12 Project ProBase • Transportation Technologies

The students are given the following scenario:

Fresh, clean water supplies throughout the world are running dangerously low, and related health concerns are becoming evident. The director of a local charitable organization has contacted your instructor and desires a vehicle to efficiently and effectively transport water from a central well to several different locations, each a different distance from the well. The conversation between the director and your instructor can be summarized by the following paragraph:

"After months of drought in several third-world nations, a number of remote villages have lost their local supply of water. People are getting very sick, animals and crops are dying. In order for families to survive, they must have transportation devices that will be used to transport fresh water to drink."

Primary Challenge



- Think about the geography of the land–are there obstacles that you might have to cross?
- How are transportation systems designed and set up within the nation's borders?
- Will you need to overcome a language barrier when communicating your ideas? How will you do this?
- Assuming the citizens will be able to purchase the necessary materials in their home country, can you stay within the budget, especially with the varying currency exchange rates?

The director has asked your instructor to assist him in developing prototype transportation devices that would be capable of transporting set amounts of water over varying distances. On average, the nearest well is 25 miles (mi) away from the remote villages. However, some families may live as much as 40 mi from the wells.

The director recognizes that, as students of a technology class, you have the abilities, knowledge, and resources to take on the challenge to devise a vehicle to transport the water in an efficient and effective manner. Since money for travel costs is not available, you will have to complete your work locally. The director has asked that you design, construct, and test your vehicle in a simulated, scaled environment, and send the plans and a materials list to them so that the vehicle can be built on location in the selected third-world nation.

It's A-Drought Time 13

Primary Challenge

Teaching Tips

You will also need three containers to hold the water for this challenge. It is recommended that your containers be open at the top so that students are challenged to design a structure and support sub-system that prevents spillage. Buckets or empty coffee cans will work fine for this challenge. Let the students know the size of the containers before they begin designing their vehicles.

Teaching Tips

You will need to assign each team to one of the following nations:

Ethiopia, Indonesia, Ecuador, Lebanon, Haiti, Mali, India, or Nicaragua.

You should begin thinking about a possible location to have your students design a course for this challenge. It should be large enough so that your students can develop a scaled course with three distinct designation points. On average, the nearest well is 40 kilometers (km) away from the remote villages. However, some families may live as much as 60 km from the wells. Keep this in mind when locating an appropriate site for this challenge.

The student vehicles must:

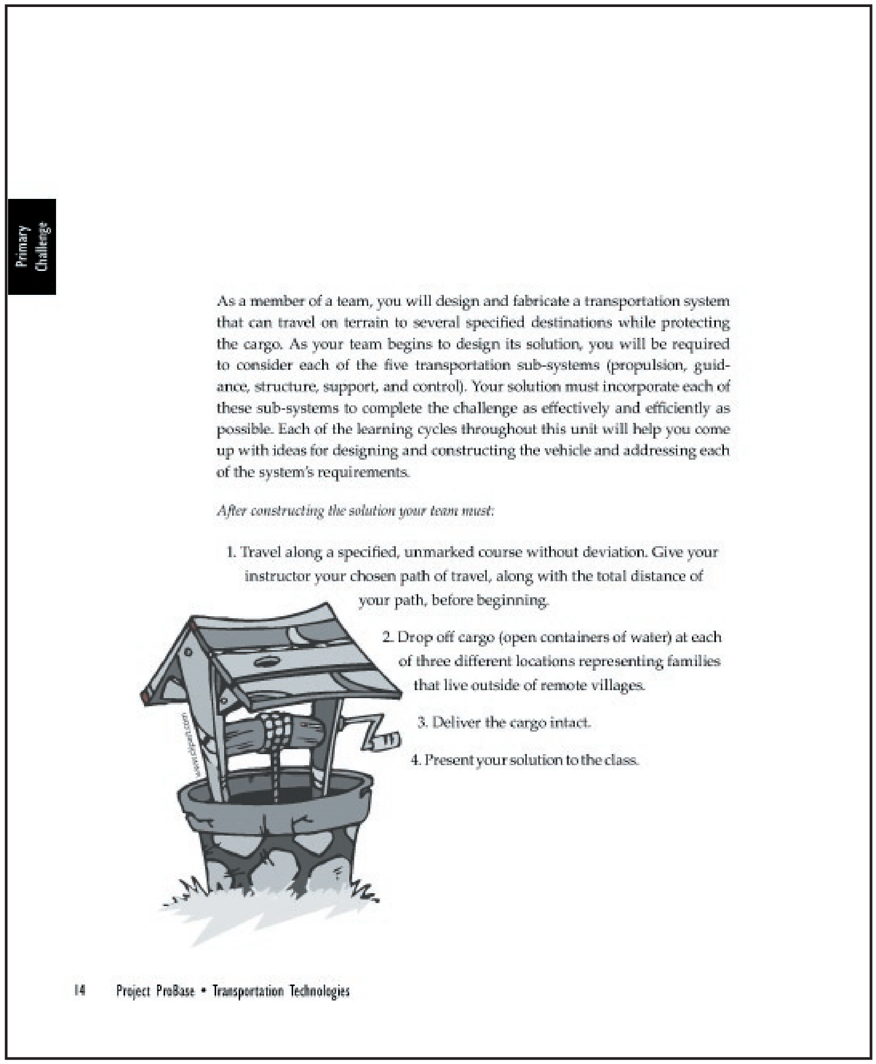
1. Travel along a specified, unmarked course without deviation. Students are asked to turn in to you their chosen path of travel, along with the total *distance* of their path. *They may use a GPS for this task, but it is not required.*

2. Drop off cargo (open containers of water) at each of the three locations.

3. Deliver the cargo intact. *Measure the amount of water spilled for each container. You could draw lines on the side of the buckets to measure amounts or weigh the bucket of water before and after the delivery.*

   You may want to take the amount of spilled water into consideration for the final results. A rubric for assessing their designed solutions is provided.

4. Students are also asked to present their solutions to the class. Presentations should include an explanation of each sub-system and describe how they worked together to carry, control, and protect the cargo.



Primary Challenge

As a member of a team, you will design and fabricate a transportation system that can travel on terrain to several specified destinations while protecting the cargo. As your team begins to design its solution, you will be required to consider each of the five transportation sub-systems (propulsion, guidance, structure, support, and control). Your solution must incorporate each of these sub-systems to complete the challenge as effectively and efficiently as possible. Each of the learning cycles throughout this unit will help you come up with ideas for designing and constructing the vehicle and addressing each of the system's requirements.

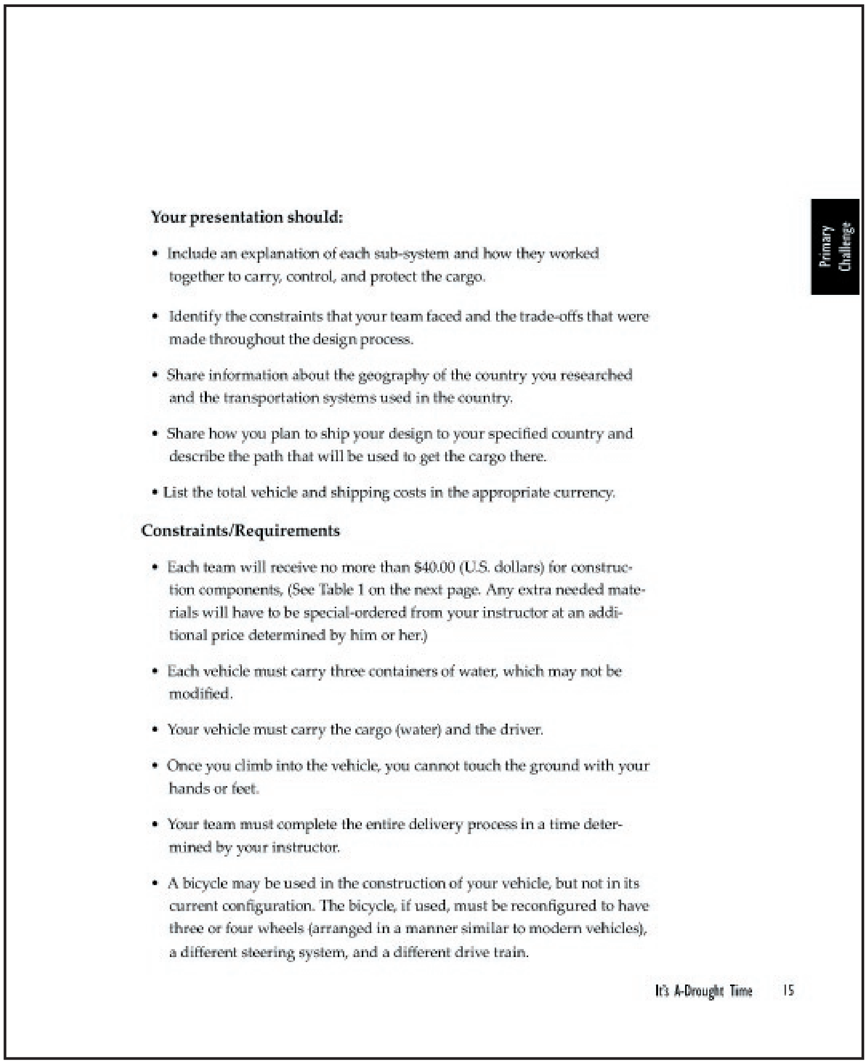
After constructing the solution your team must:

1. Travel along a specified, unmarked course without deviation. Give your instructor your chosen path of travel, along with the total distance of your path, before beginning.
2. Drop off cargo (open containers of water) at each of three different locations representing families that live outside of remote villages.
3. Deliver the cargo intact.
4. Present your solution to the class.

14 Project ProBase • Transportation Technologies

During the presentation, students must:

- Deliver engaging, interesting, and informative presentations for other students.
- Share information about the geography of the country they were assigned and explain how the transportation system was designed for that country.



Primary Challenge

Your presentation should:

- Include an explanation of each sub-system and how they worked together to carry, control, and protect the cargo.
- Identify the constraints that your team faced and the trade-offs that were made throughout the design process.
- Share information about the geography of the country you researched and the transportation systems used in the country.
- Share how you plan to ship your design to your specified country and describe the path that will be used to get the cargo there.
- List the total vehicle and shipping costs in the appropriate currency.

Constraints/Requirements

- Each team will receive no more than $40.00 (U.S. dollars) for construction components, (See Table 1 on the next page. Any extra needed materials will have to be special-ordered from your instructor at an additional price determined by him or her.)
- Each vehicle must carry three containers of water, which may not be modified.
- Your vehicle must carry the cargo (water) and the driver.
- Once you climb into the vehicle, you cannot touch the ground with your hands or feet.
- Your team must complete the entire delivery process in a time determined by your instructor.
- A bicycle may be used in the construction of your vehicle, but not in its current configuration. The bicycle, if used, must be reconfigured to have three or four wheels (arranged in a manner similar to modern vehicles), a different steering system, and a different drive train.

It's A-Drought Time 15

- Outline plans for shipping solutions to the specified country, identify the route intended for shipping the cargo, and provide an estimate of shipping costs using appropriate currency.

Encourage students to use appropriate presentation techniques such as maps, computer generated images, and presentation software during their presentations. A rubric for assessing their presentation is provided.

Teaching tips

Remind students to talk about each of the sub-systems, ways they implemented the sub-system, and how they arrived at a solution to the *Primary Challenge*.

One of the constraints states that each student team must complete the entire delivery process within a time determined by the instructor. You will need to determine an appropriate time based on your course and students' abilities. It is recommended that you let your students decide an appropriate time limit as a class once the course has been identified.

Teaching Tips

The constraints specify that the solution must carry the driver while carrying three open containers of water. One container of water will be dropped off at each of the three sites and a different member of the team must be transported to the next location. The constraints do not specify the route that each team must travel. This is left to each team's discretion. Because there are multiple plausible paths for this solution, each team should give you its selected path before beginning.

Materials	Cost per item (in U. S. dollars):
2" PVC pipe (10 ft. length)	3.00
1.5" PVC pipe (10 ft. length)	2.50
90° Elbow (2")	.70
90° Elbow (1.5")	.60
45° Elbow (2")	.70
45° Elbow (1.5")	.60
Straight T (2")	1.20
Straight T (1.5")	1.00
Y (2")	1.25
Y (1.5")	1.00
Coupling (2")	.55
Coupling (1.5")	.40
4 Wheels	10.00
2 Axles	3.00

Table 1. *Materials pricing list*

Note: Your instructor may modify this list or the requirements for this *Primary Challenge*. Make sure you understand the requirements for your solution before beginning your design.

Teaching Tips

As you present this *Primary Challenge* to your students and discuss their questions, you should highlight how important it will be for them to design a structure that will support the weight of the heaviest person on their team. If this is problematic for your students, there are several ways to work around this issue. One suggestion is to have students from a lower grade level participate in the task by driving the vehicles. Another solution is to increase the diameter of the PVC pipe. This will reduce the flex of the pipe. The flex can also be reduced through a structural design that incorporates multiple triangles. Another suggestion is to incorporate an old bicycle into their designs. However, if students choose to incorporate a bicycle, remind them that the bicycle cannot be used in its current configuration.

Materials	Cost per item (in U. S. dollars):
2" PVC pipe (10 ft. length)	3.00
1.5" PVC pipe (10 ft. length)	2.50
90-degree elbow (2")	.70
90-degree elbow (1.5")	.60
45-degree elbow (2")	.70
45-degree elbow (1.5")	.60
Straight T (2")	1.20
Straight T (1.5")	1.00
Y (2")	1.25
Y (1.5")	1.00
Coupling (2")	.55
Coupling (1.5")	.40
4 wheels	5.00
2 axles	3.00

Table 1. *Materials pricing list*

Facility Requirements

The construction of the students' solutions can be completed in a regular lab setting. However, the testing of the students' solutions will need to be conducted in a large space, such as the school's gymnasium or cafeteria, or outside.

Equipment and Materials

Based on a class of 28 students:

The materials and equipment needed will vary according to the students' solutions to this challenge. In an effort to vary the solutions and challenge the students to consider trade-offs during their development work, a list of materials and their costs in U.S. dollars is provided in the student edition. PVC was selected as a construction material because it is readily available in most communities, offers a high weight to strength ratio, is easily worked with using common tools, and comes in a variety of sizes and shapes of connectors.

Student teams will be required to submit a materials list prior to constructing their solutions. Their list should show both U.S. dollars and the currency used by their country. It is recommended that you purchase one of each item on the list so that the students can see and touch each part as they design their solutions.

If a bicycle is not easily obtainable, encourage students to brainstorm other freely obtainable materials and objects. Remind them that their solution will have to be reproducible in another nation, so that might limit the use of some materials.

Teaching Tips

After going through the *Preliminary Challenge* and introducing the *Primary Challenge*, you will need to divide your class into teams. After observing students during the *Preliminary Challenge*, you should have a better idea of which combinations of students will make the most effective teams.

Teaching Tips

After you have assigned teams and specified their "nation," each team will need some time to work together. Some of the task can be assigned as homework; however, it is recommended that you provide one class period at this time for teams to begin working together on the following task:

> Have students conduct work on their assigned country. They should be looking for, the terrain native to the country as well as the currency exchange rate. The currency exchange rate fluctuates regularly. Therefore, you will need to assign a date for each team to use as a basis for calculation. An alternative that would sharpen students' mathematics skills would be to have them use an average exchange rate taken over a specified period of time. This would require that students look for the exchange rate daily and then find the mean rate for the specified length of time.

A larger version of the materials and cost table (***Table 1***) is found on the previous page.

Teaching Tips

In a constructivist-based Learning Unit, it is important to focus on conceptual development. Therefore, it will be important for your class to stop and check for understanding from time to time throughout this unit. The students' Inventor's Logbook entries will serve as one means to check their progress on a regular basis. Here are a few other strategies that may help you keep your students focused on their conceptual development.

- Create a large poster with the key concepts and/or enduring understandings and place it in a prominent spot in your classroom (An example layout can be found in the Appendix).
- Break students into their *Primary Challenge* teams and identify what they know and what they need to know to solve the *Primary Challenge*. Compile a list of questions that must be answered in order to solve the challenge. Create a large class display that lists these questions and require the students (or teams) to "check off" the questions that have been answered during the course of the Learning Unit. This has been found to be very helpful in our test sites.
- Have your students create concept maps of the unit. This can be done individually or in small teams.

Primary Challenge Rubric

Element	Criteria				Points
Point Values	40	30	20	10	
Primary Challenge Product	Completed product is fully functional and addresses all criteria, parameters, and equipment specifications set forth in the *Primary Challenge.*	Completed product is functional and meets most criteria, parameters, and equipment specifications set forth in the *Primary Challenge.*	Completed product represents a serious attempt to solve the *Primary Challenge,* but does not address many of the stated criteria, parameters, or specifications.	Product is not complete or does not function well and does not meet stated criteria, parameters, or specifications.	
				Sub-total	
Point Values	15	10	5	2	
Drawings, Diagrams, & Sketches	Drawings, diagrams, or sketches clearly illustrate an understanding of all requirements, criteria, or specifications; uses proper format; and was completed electronically.	Drawings, diagrams, or sketches illustrate needed information, but do not address all stated requirements, specifications, or criteria. Completed using an electronic format.	Drawings, diagrams, or sketches illustrate needed information, but do not address all stated requirements, specifications, or criteria. Did not utilize an electronic format (hand drawn).	Drawings, diagrams, or sketches do not illustrate all needed information. Illustrations are incomplete or poorly presented.	
Research & Development	Clear evidence of a comprehensive research and development effort was provided.	Research and development was conducted while solving the primary challenge, but documentation was marginal.	Some research and development techniques were used while attempting to solve the *Primary Challenge*, but were not clearly documented.	Minimal research and development techniques were used while attempting to solve the *Primary Challenge*. Documentation was marginal.	
Documentation	As directed, the team responded to questions and/or maintained comprehensive records, logs, and other notations of activities while completing the *Primary Challenge*.	Team responded to questions and/or maintained topical records, logs, and other notations of activities while completing the *Primary Challenge*.	Team responded to most questions and/or maintained some records, logs, and other notations of activities while completing the *Primary Challenge*.	Team marginally responded to questions and did not maintain records, logs, and other notations of activities while completing the *Primary Challenge*.	
Presentation	Presentation demonstrates a full grasp of the major concepts, addresses all stated presentation requirements, and conforms to time limit constraints.	Presentation demonstrates significant understanding of major concepts, addresses most presentation requirements, and conforms to time limitations.	Presentation topically addresses some of the concepts delivered in this unit, but does not conform to stated presentation guidelines and/or time limits.	Presentation does not demonstrate a grasp of the major concepts delivered in this unit and/or does not address stated presentation guidelines or time limits.	
				Total Points	

Learning Cycle One

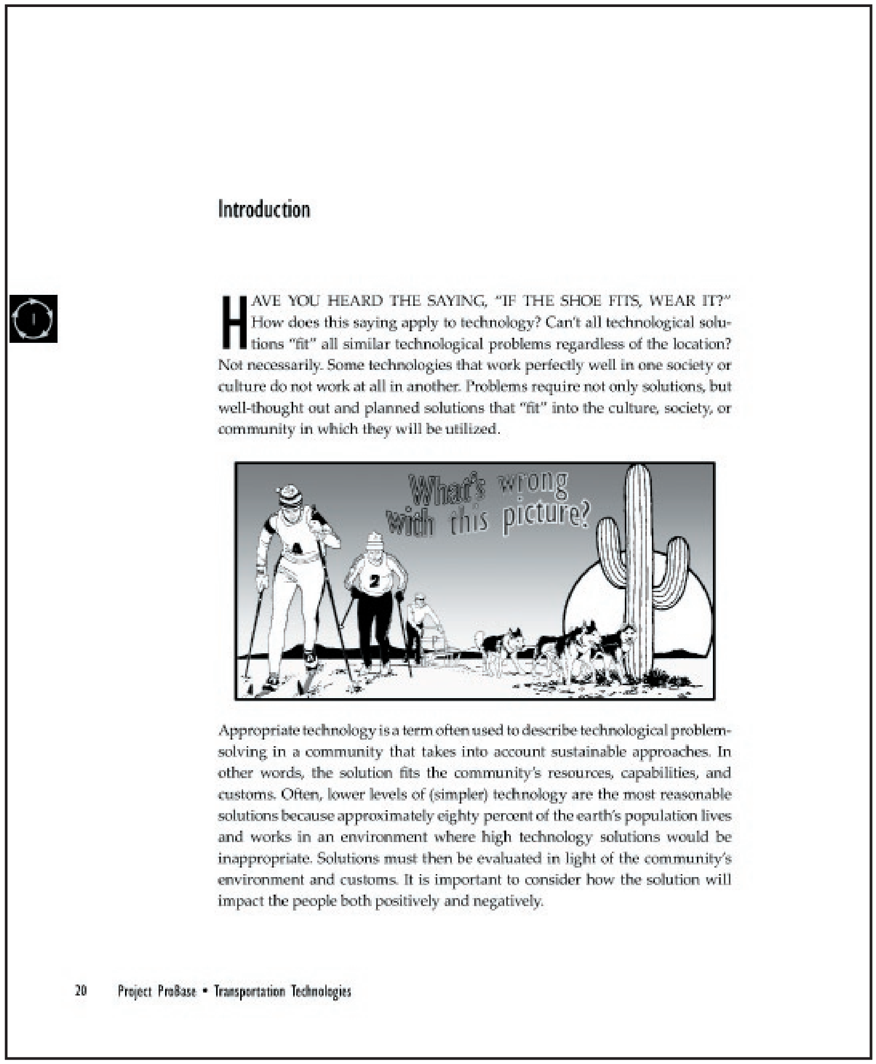
The Right Fit

The Right Fit

Introduction

The goal for this learning cycle is to introduce students to the concept of appropriate technology. Appropriate technology is technological problem-solving that considers the needs of the community. In fact, appropriate technology takes into account sustainable approaches that fit the community's resources, capabilities, and customs. In this learning cycle, students will continue conducting research on the country that was assigned to their design team for the *Primary Challenge.*

Students should begin to understand the importance of conducting research and understanding their assigned nation's culture and environment in designing their *Primary Challenge* solution and in solving the challenges faced in this learning cycle. While working through this learning cycle, students should be continually reminded that their solution to the *Primary Challenge* should be designed and constructed so that it will be appropriate and sustainable for their assigned nation. The activities included in this learning cycle are designed to stimulate that thought process.



Introduction

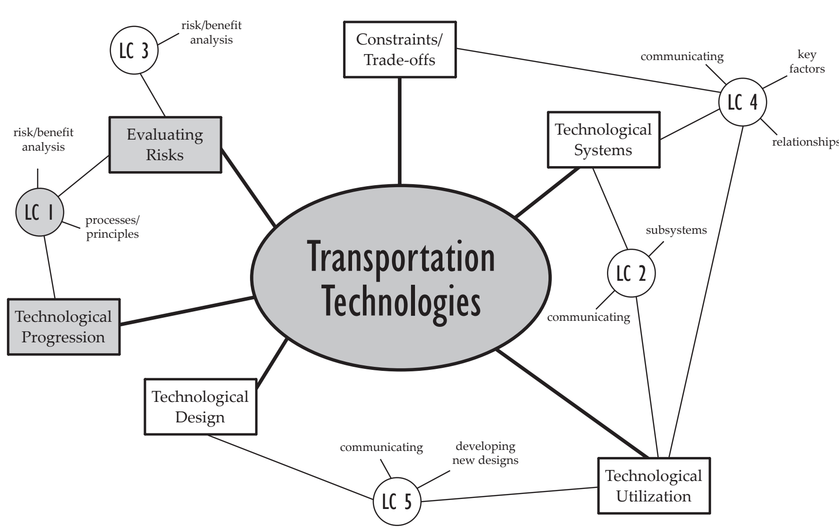
HAVE YOU HEARD THE SAYING, "IF THE SHOE FITS, WEAR IT?" How does this saying apply to technology? Can't all technological solutions "fit" all similar technological problems regardless of the location? Not necessarily. Some technologies that work perfectly well in one society or culture do not work at all in another. Problems require not only solutions, but well-thought out and planned solutions that "fit" into the culture, society, or community in which they will be utilized.

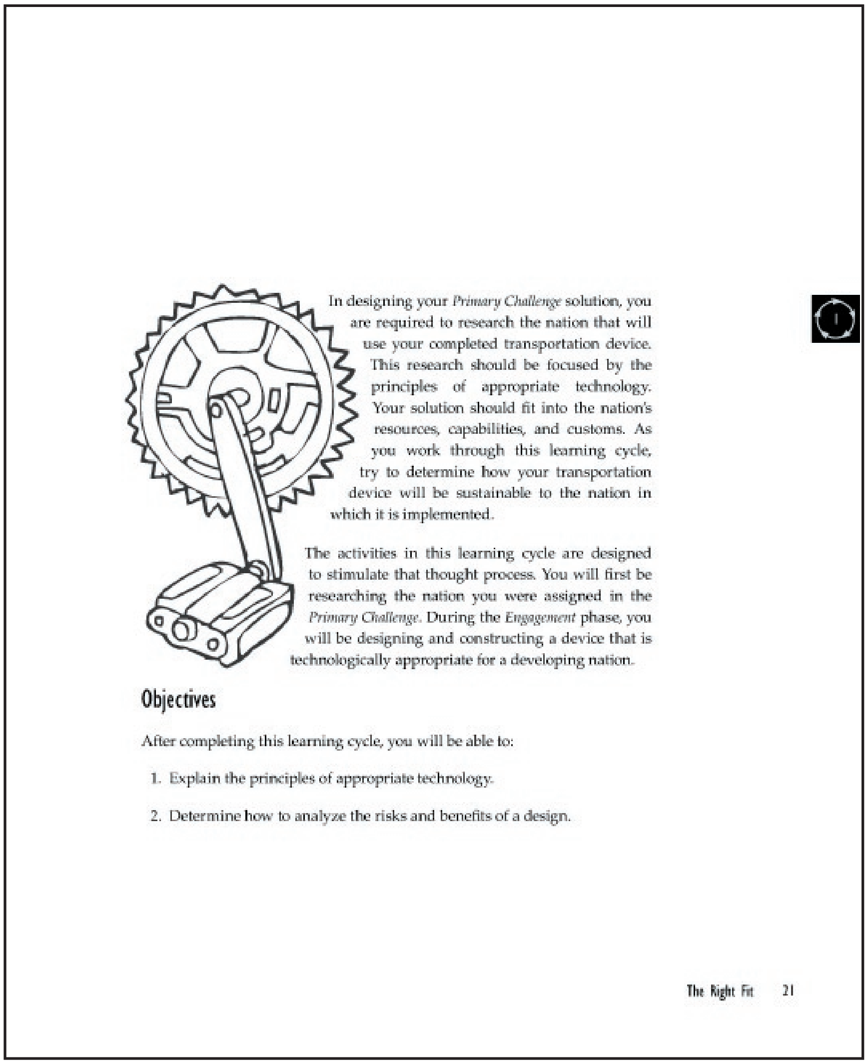
What's wrong with this picture?

Appropriate technology is a term often used to describe technological problem-solving in a community that takes into account sustainable approaches. In other words, the solution fits the community's resources, capabilities, and customs. Often, lower levels of (simpler) technology are the most reasonable solutions because approximately eighty percent of the earth's population lives and works in an environment where high technology solutions would be inappropriate. Solutions must then be evaluated in light of the community's environment and customs. It is important to consider how the solution will impact the people both positively and negatively.

20 Project ProBase • Transportation Technologies

Transportation Technologies
Learning Cycle One Concept Map





In designing your *Primary Challenge* solution, you are required to research the nation that will use your completed transportation device. This research should be focused by the principles of appropriate technology. Your solution should fit into the nation's resources, capabilities, and customs. As you work through this learning cycle, try to determine how your transportation device will be sustainable to the nation in which it is implemented.

The activities in this learning cycle are designed to stimulate that thought process. You will first be researching the nation you were assigned in the *Primary Challenge*. During the *Engagement* phase, you will be designing and constructing a device that is technologically appropriate for a developing nation.

Objectives

After completing this learning cycle, you will be able to:

1. Explain the principles of appropriate technology.
2. Determine how to analyze the risks and benefits of a design.

The Right Fit 21

During the *Exploration* activity students will be researching one of the nations they were assigned for the *Primary Challenge*. This will provide them an opportunity to learn about their nation in a structured way. During the *Engagement* phase, students will be examining pedal power in designing a device to complete a domestic chore. Although the activity is not directly connected to the *Primary Challenge* problem, pedal power is a potential component that can be incorporated into their solutions.

Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Explain the principles of appropriate technology.
   Essential Question 1e: What are the fundamental processes/principles used to develop new technologies?

2. Determine how to analyze the risks and benefits of a design.
   Essential Question 8a: How does a risk/benefit analysis aid the designer in addressing potential harmful effects prior to development?

Facility Requirements

This learning cycle can be completed in a regular classroom. Students will need to use computers that have Internet access to conduct their research. They will also need enough space to construct their devices.

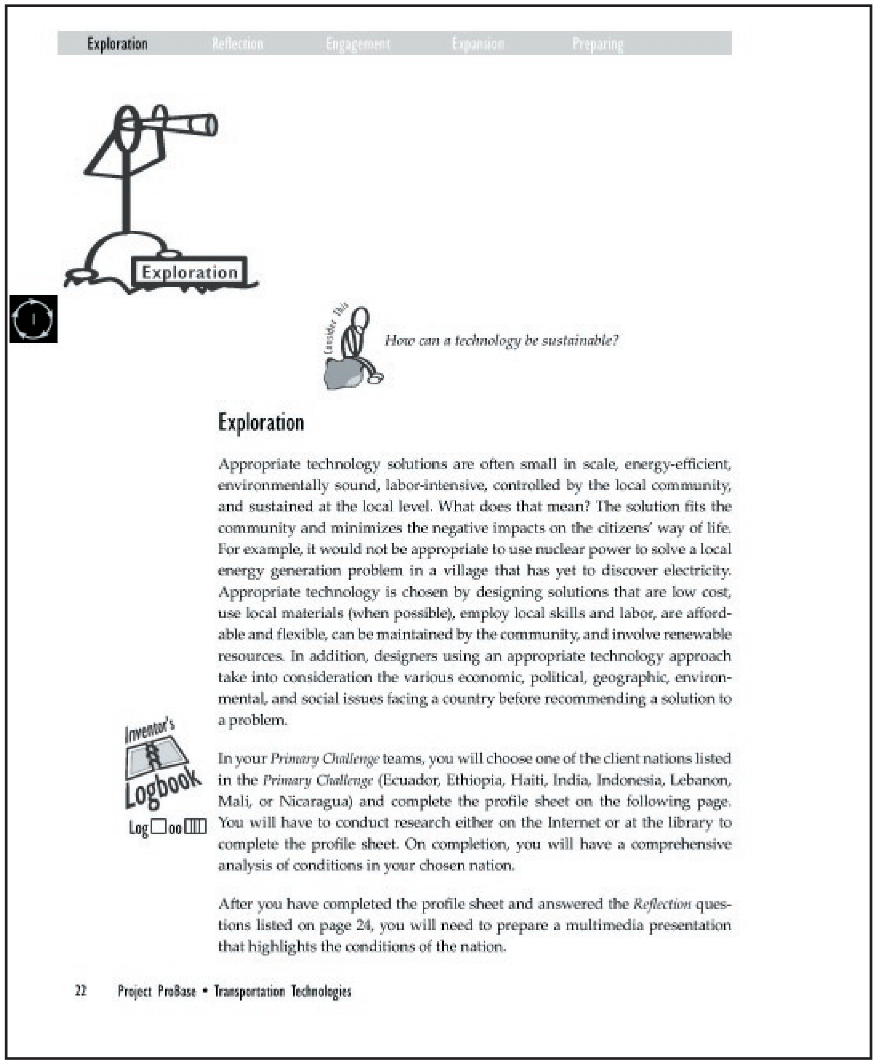
Equipment and Materials

Based on a class of 28 students:

Engagement materials will vary and may include recyclable materials or discarded objects

Optional:

Plastic buckets
Used bicycles
Wood slats
Nuts and bolts
Nails
Hammers



Exploration Reflection Engagement Expansion Preparing

How can a technology be sustainable?

Exploration

Appropriate technology solutions are often small in scale, energy-efficient, environmentally sound, labor-intensive, controlled by the local community, and sustained at the local level. What does that mean? The solution fits the community and minimizes the negative impacts on the citizens' way of life. For example, it would not be appropriate to use nuclear power to solve a local energy generation problem in a village that has yet to discover electricity. Appropriate technology is chosen by designing solutions that are low cost, use local materials (when possible), employ local skills and labor, are affordable and flexible, can be maintained by the community, and involve renewable resources. In addition, designers using an appropriate technology approach take into consideration the various economic, political, geographic, environmental, and social issues facing a country before recommending a solution to a problem.

In your *Primary Challenge* teams, you will choose one of the client nations listed in the *Primary Challenge* (Ecuador, Ethiopia, Haiti, India, Indonesia, Lebanon, Mali, or Nicaragua) and complete the profile sheet on the following page. You will have to conduct research either on the Internet or at the library to complete the profile sheet. On completion, you will have a comprehensive analysis of conditions in your chosen nation.

After you have completed the profile sheet and answered the *Reflection* questions listed on page 24, you will need to prepare a multimedia presentation that highlights the conditions of the nation.

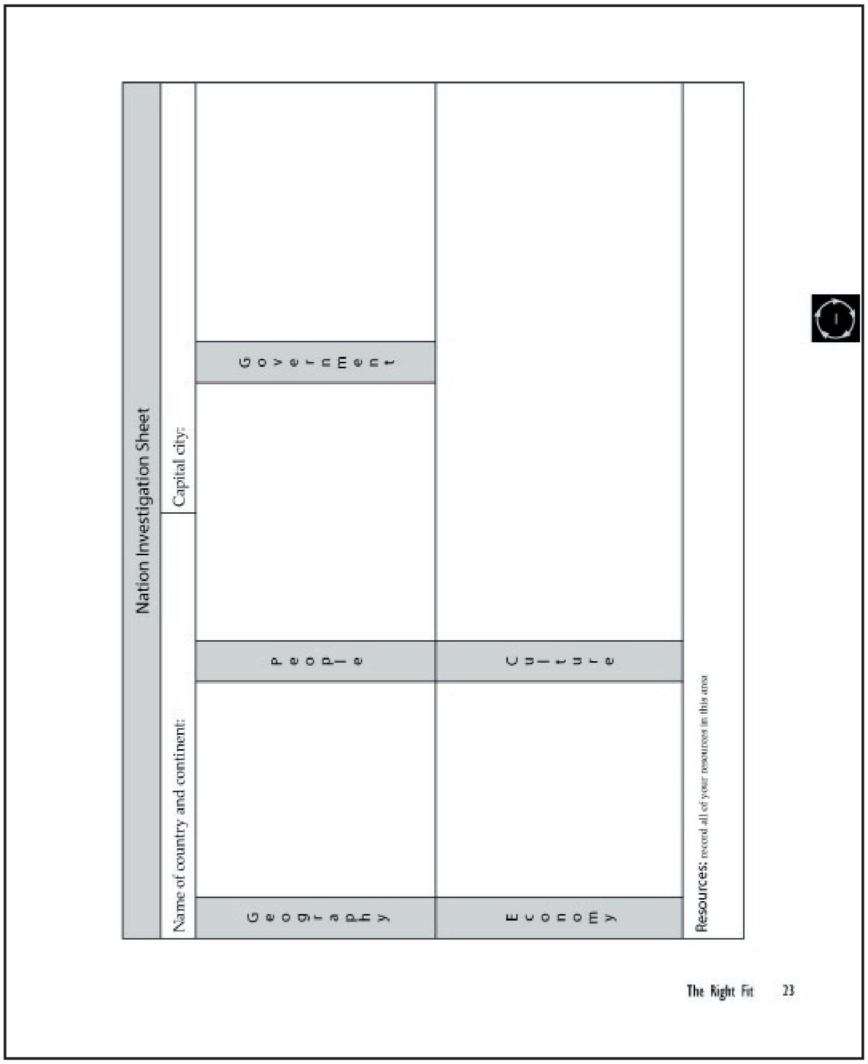
22 Project ProBase • Transportation Technologies

Suggested Daily Outline

Day One	Day Two	Day Three
Introduction, *Exploration*	*Exploration* *Reflection*	*Engagement*

Day Four	Day Five
Engagement	*Engagement* *Preparing for the Challenge*

Estimated number of 50-minute class periods: **5**


Nation Investigation Sheet

Name of country and continent:

Capital city:

Geography	People	Government

Economy	Culture

Resources: record all of your resources in this area

The Right Fit 23

Teaching Tips

You may want to direct students to the CIA World Factbook. The Factbook is an excellent resource available online that can help the students complete their profile sheet. The site is located at http://www.odci.gov/cia/publications/factbook/index.html

Exploration

In their *Primary Challenge* teams, students are asked to research their team's client nation and complete the profile sheet. This research will help the students design technologically appropriate solutions for the *Primary Challenge*. You may decide to use each team's completed profile sheet to evaluate their *Primary Challenge* solutions to determine how "appropriate" they are.

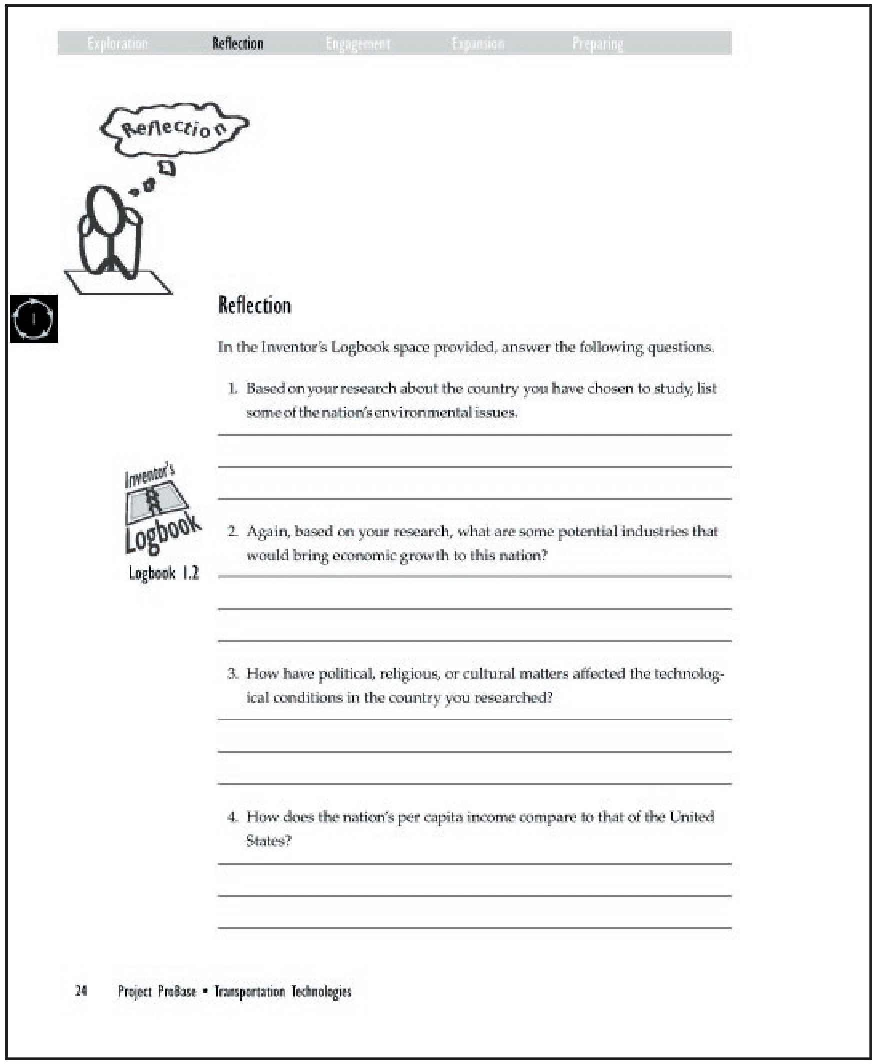
Before students can begin to make judgments on the appropriateness of technology, they must have an understanding of the region or nation in question. There are twelve common characteristics for determining the appropriateness of a given technology. These characteristics can be shared with the class to help guide each team's research. The twelve common characteristics are listed to the right.

An appropriate technology:

- Adresses the well-being of the indigenous population.
- Takes into account environmental issues.
- Benefits society.
- Solves problems and satisfies particular needs of the community.
- Takes into account the culture of the indigenous population.
- Includes a collective effort in its creation, implementation, and maintenance.
- Is cost effective for the end user.
- Is sustainable by the user.
- Utilizes local and renewable resources whenever possible.
- Has multiple benefits.
- Allows for the continuation of development.
- Has an "image of modernity," whenever possible.

Reflection

Students are asked to answer the following questions in their Inventor's Logbook.


Exploration Reflection Engagement Expansion Preparing

Reflection

Inventor's Logbook

Logbook 1.2

Reflection

In the Inventor's Logbook space provided, answer the following questions.

1. Based on your research about the country you have chosen to study, list some of the nation's environmental issues.
2. Again, based on your research, what are some potential industries that would bring economic growth to this nation?
3. How have political, religious, or cultural matters affected the technological conditions in the country you researched?
4. How does the nation's per capita income compare to that of the United States?

24 Project ProBase • Transportation Technologies

1. Based on your research about the country you have chosen to study, list some of the nation's environmental issues.

   Answers will vary. Students should explore some of the environmental concerns plaguing the nation, along with the natural resources that may either be endangered or that should be protected.

2. Again, based on your research, what are some potential industries that would bring economic growth to this nation?

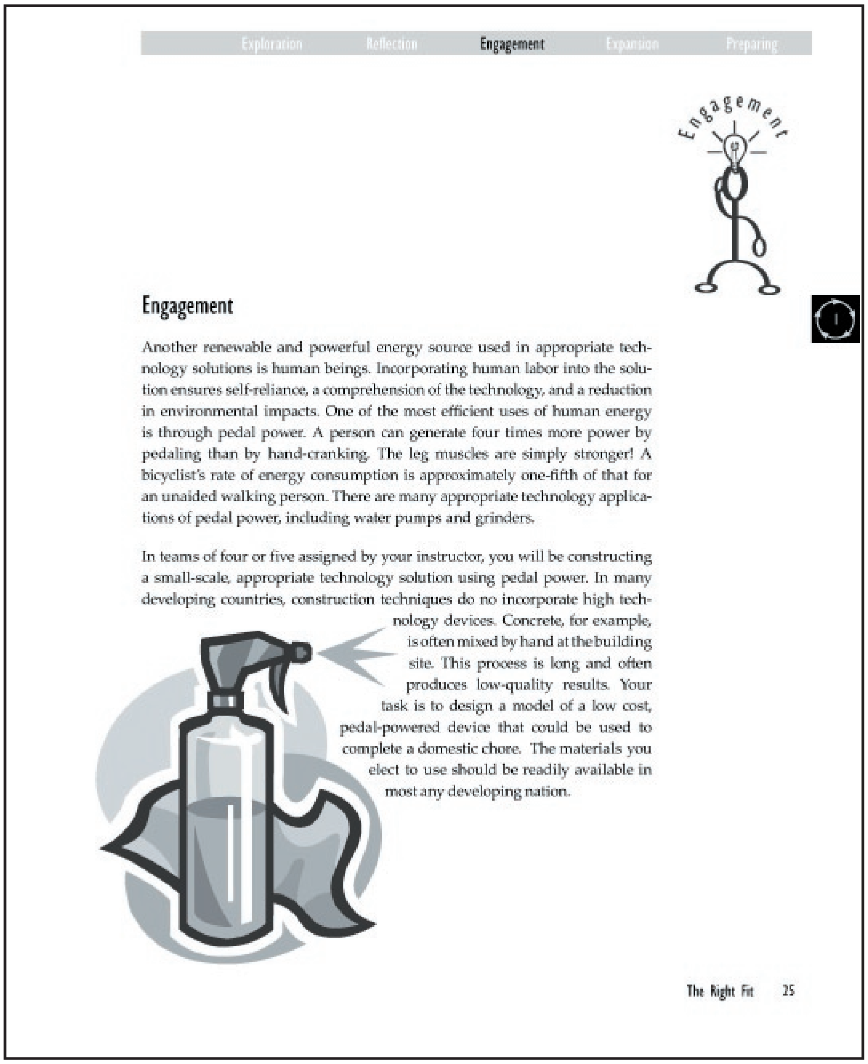
   Answers will vary. Economic growth is most likely a major concern of many of the client nations. Students can explore some of the initiatives that have been used or are currently being attempted to stimulate growth. Students may have ideas of their own based on their findings and answers to the first question. Some nation's natural resources may be exploited for economic growth.

3. How have political, religious, or cultural matters affected the technological conditions in the country?

   Answers will vary. A region's beliefs can affect the technological conditions of the region. Students should explore this concept and analyze how their Primary Challenge solution should adapt to their findings.

4. How does the nation's per capita income compare to that of the United States?

   Answers will vary.



Exploration Reflection Engagement Expansion Preparing

Engagement

Engagement

Another renewable and powerful energy source used in appropriate technology solutions is human beings. Incorporating human labor into the solution ensures self-reliance, a comprehension of the technology, and a reduction in environmental impacts. One of the most efficient uses of human energy is through pedal power. A person can generate four times more power by pedaling than by hand-cranking. The leg muscles are simply stronger! A bicyclist's rate of energy consumption is approximately one-fifth of that for an unaided walking person. There are many appropriate technology applications of pedal power, including water pumps and grinders.

In teams of four or five assigned by your instructor, you will be constructing a small-scale, appropriate technology solution using pedal power. In many developing countries, construction techniques do no incorporate high technology devices. Concrete, for example, is often mixed by hand at the building site. This process is long and often produces low-quality results. Your task is to design a model of a low cost, pedal-powered device that could be used to complete a domestic chore. The materials you elect to use should be readily available in most any developing nation.

The Right Fit 25

Engagement

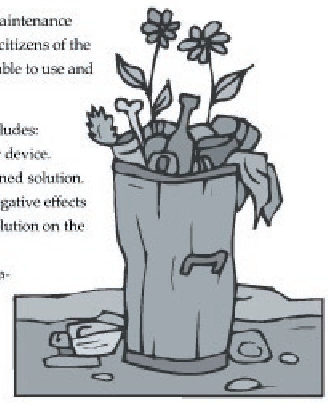
In teams of four or five assigned by you, students will be constructing an appropriate technology device using pedal power. Pedal power is an important resource for appropriate technology and may be an option for students' *Primary Challenge* solutions. Their task for the *Engagement* activity is to design a low-cost device to complete a domestic chore that can be constructed using materials available in most any developing nation.

Students should first identify a domestic chore that could be improved with a technological device. Students can use their research findings to target a device for their *Primary Challenge* nation. Some examples of pedal-powered devices include concrete mixers, generators, corn grinders, and water pumps.

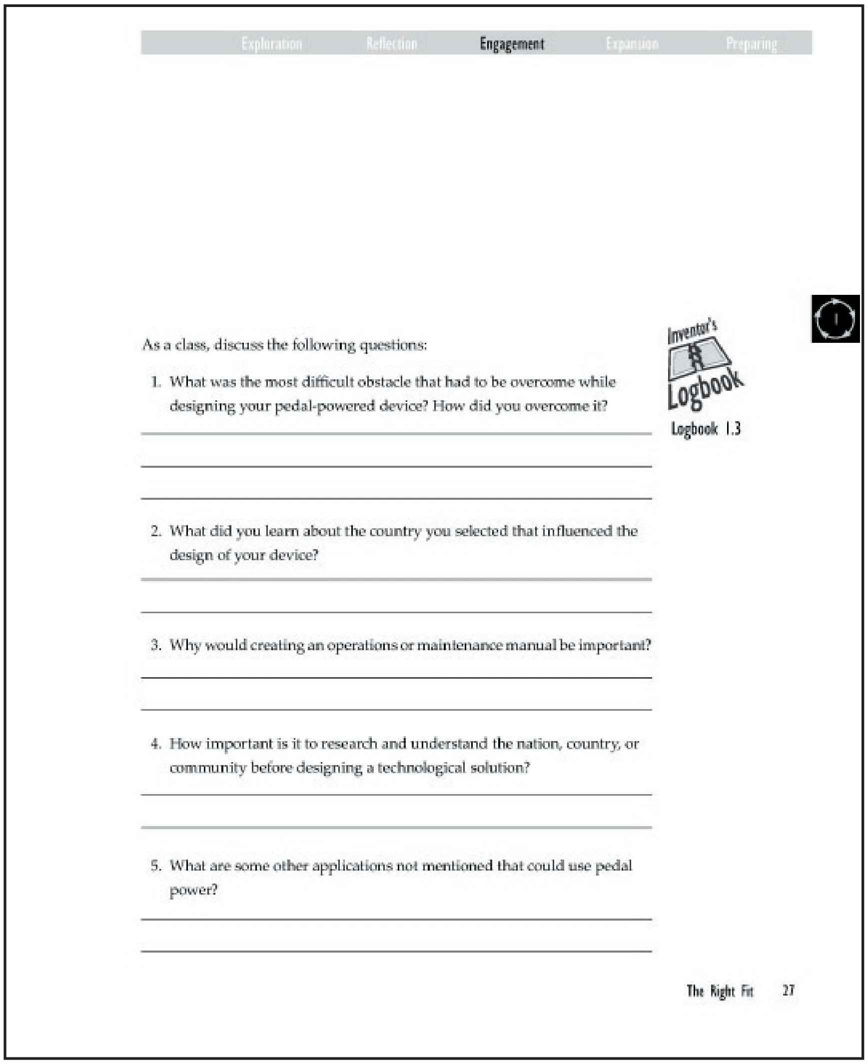
Students are asked to use only recyclable or freely obtained resources for their device. Each team should submit a materials list prior to construction so you can help them locate the necessary materials. Students should be encouraged to bring in materials from their homes. In addition, you may decide to provide them with wood, nuts, bolts, screws, nails, and hand tools.

Follow the directions below to design and construct your device:

1. Select a country where your solution will be implemented and identify the available materials, equipment, and resources.
2. Use only recycled or freely obtainable materials.
3. Submit a list of materials to your instructor and, with your instructor's help, gather the materials.
4. Develop a device that will complete a domestic task. Think about a task that really needs to be accomplished in this nation.
5. Develop an operations and maintenance manual that ensures that the citizens of the country you selected will be able to use and repair the device.
6. Create a presentation that includes:
   a. A demonstration of your device.
   b. The merits of your designed solution.
   c. Potential positive and negative effects of implementing your solution on the country.
   d. A discussion of the operations and maintenance manual.



Notes:



Exploration Reflection Engagement Expansion Preparing

Inventor's Logbook

Logbook 1.3

As a class, discuss the following questions:

1. What was the most difficult obstacle that had to be overcome while designing your pedal-powered device? How did you overcome it?
2. What did you learn about the country you selected that influenced the design of your device?
3. Why would creating an operations or maintenance manual be important?
4. How important is it to research and understand the nation, country, or community before designing a technological solution?
5. What are some other applications not mentioned that could use pedal power?

The Right Fit 27

After students have presented their devices, lead a class discussion using the following questions:

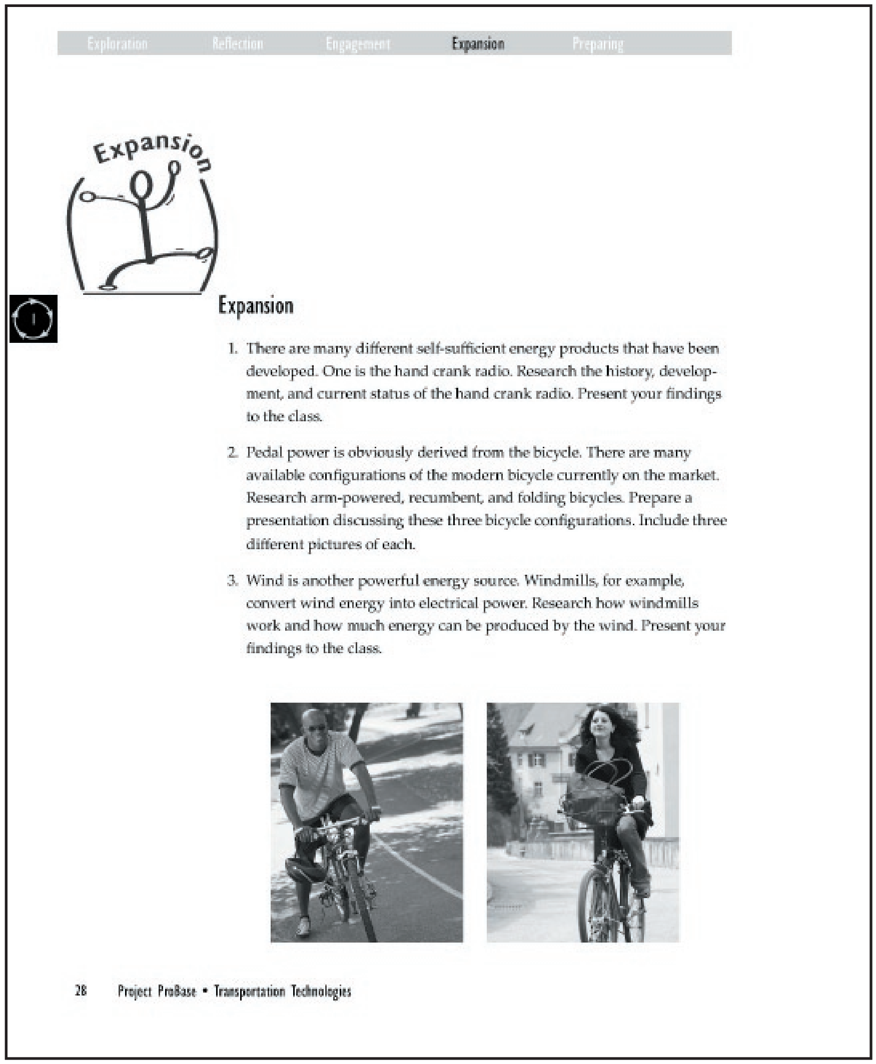
1. What was the most difficult obstacle that had to be overcome while designing your pedal-powered device? How did you overcome it?
   Answers may vary.

2. What did you learn about the country you selected that influenced the design of your device?
   Answers may vary. Students should provide at least one example of how an aspect of the country impacted the design. For example, the materials they chose.

3. Why would creating an operations and maintenance manual be important?
   The manual will ensure sustainability. Technologies implemented without some kind of manual will not last, because once they fail or break and the local population does not know how or have the materials available to fix them, they may be abandoned.

4. How important is it to research and understand the nation, country, or community before designing a technological solution?
   Students should now recognize the importance of understanding a community's culture and environment when designing solutions to problems.

5. What are some other applications not mentioned that could use pedal power?
   Mills, extractors, air compressors, transportation devices, etc.


Exploration Reflection Engagement Expansion Preparing

Expansion

1. There are many different self-sufficient energy products that have been developed. One is the hand crank radio. Research the history, development, and current status of the hand crank radio. Present your findings to the class.
2. Pedal power is obviously derived from the bicycle. There are many available configurations of the modern bicycle currently on the market. Research arm-powered, recumbent, and folding bicycles. Prepare a presentation discussing these three bicycle configurations. Include three different pictures of each.
3. Wind is another powerful energy source. Windmills, for example, convert wind energy into electrical power. Research how windmills work and how much energy can be produced by the wind. Present your findings to the class.

28 Project ProBase • Transportation Technologies

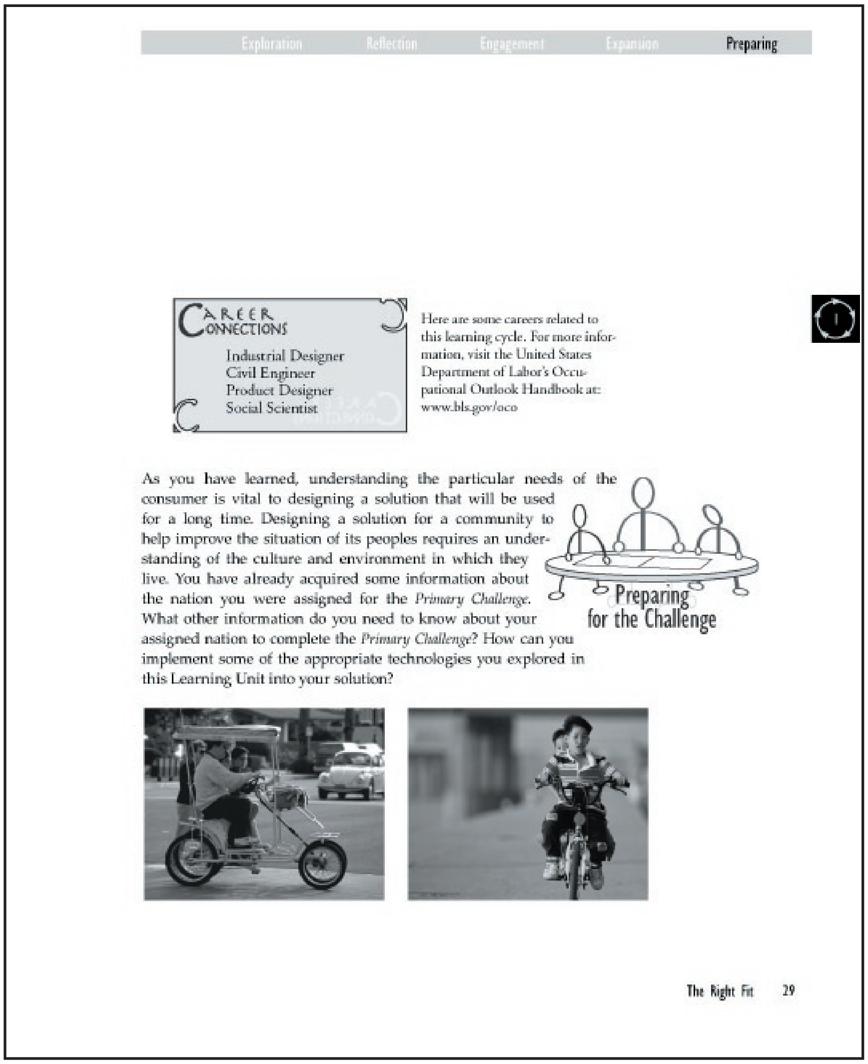
Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

1. There are many different self-sufficient energy products that have been developed. One is the hand crank radio. Research the history, development, and current status of the hand crank radio. Present your findings to the class.

2. Pedal power is obviously derived from the bicycle. There are many available configurations of the modern bicycle currently on the market. Research arm-powered, recumbent, and folding bicycles. Prepare a presentation discussing these three bicycle configurations. Include three different pictures of each.

3. Wind is another powerful energy source. Windmills, for example, convert wind energy into electrical power. Research how windmills work and how much energy can be produced by the wind. Present your findings to the class.


Exploration Reflection Engagement Expansion Preparing

Career Connections

Industrial Designer
Civil Engineer
Product Designer
Social Scientist

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

As you have learned, understanding the particular needs of the consumer is vital to designing a solution that will be used for a long time. Designing a solution for a community to help improve the situation of its peoples requires an understanding of the culture and environment in which they live. You have already acquired some information about the nation you were assigned for the *Primary Challenge*. What other information do you need to know about your assigned nation to complete the *Primary Challenge*? How can you implement some of the appropriate technologies you explored in this Learning Unit into your solution?

Preparing for the Challenge

The Right Fit 29

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

Preparing for the Challenge

After students complete the *Expansion* activity, ask them to meet in their *Primary Challenge* teams and work through the questions in their student guides. Most teams will need to do additional research on their assigned nation in order to complete their solutions. You may decide to bring the whole class together and discuss how students may incorporate some of the appropriate technologies they explored in the learning cycle into their *Primary Challenge* solutions.

The Right Fit

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Exploration	Completed profile sheet with exceptional quality and delivered an excellent presentation.	Completed profile sheet with above average quality and delivered a very good presentation.	Completed profile sheet with average quality and delivered a good presentation.	Completed profile sheet with poor quality and delivered a poor presentation.	
Engagement	Completed a device and manual with exceptional quality and delivered an excellent presentation.	Completed a device and manual with above average quality and delivered a very good presentation.	Completed a device and manual with average quality and delivered a good presentation.	Completed a device and manual with poor quality and delivered a poor presentation.	
Inventor's Logbook Entries	Fully answered all entries and provided good examples.	Answered most of the entries and provided some examples.	Answered few entries and provided few examples.	Did not answer entries and did not provide examples.	
				Total Points	

Learning Cycle Two

2

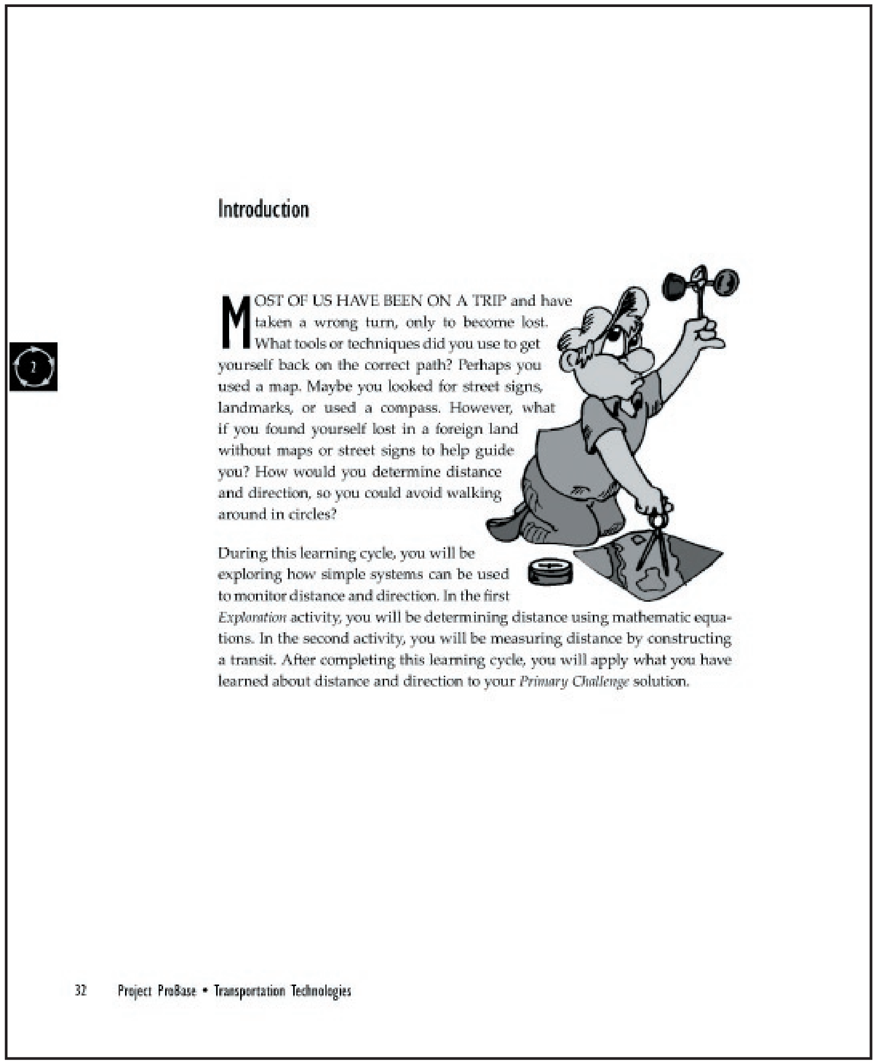
Plotting the Course

Plotting the Course

Introduction

The primary goal of this learning cycle is for students to learn about determining distance and direction. In the *Exploration* phase, the students will calculate distance using mathematics and then construct a transit.

During the *Engagement* activity, students will have the opportunity to expand upon those concepts by using the transit to measure distance. These activities will provide the knowledge needed as part of the solution to the *Primary Challenge.*



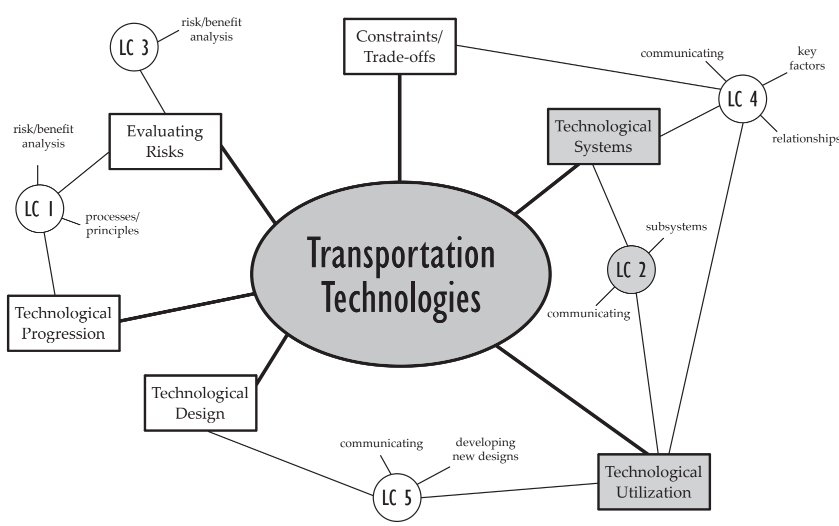
Introduction

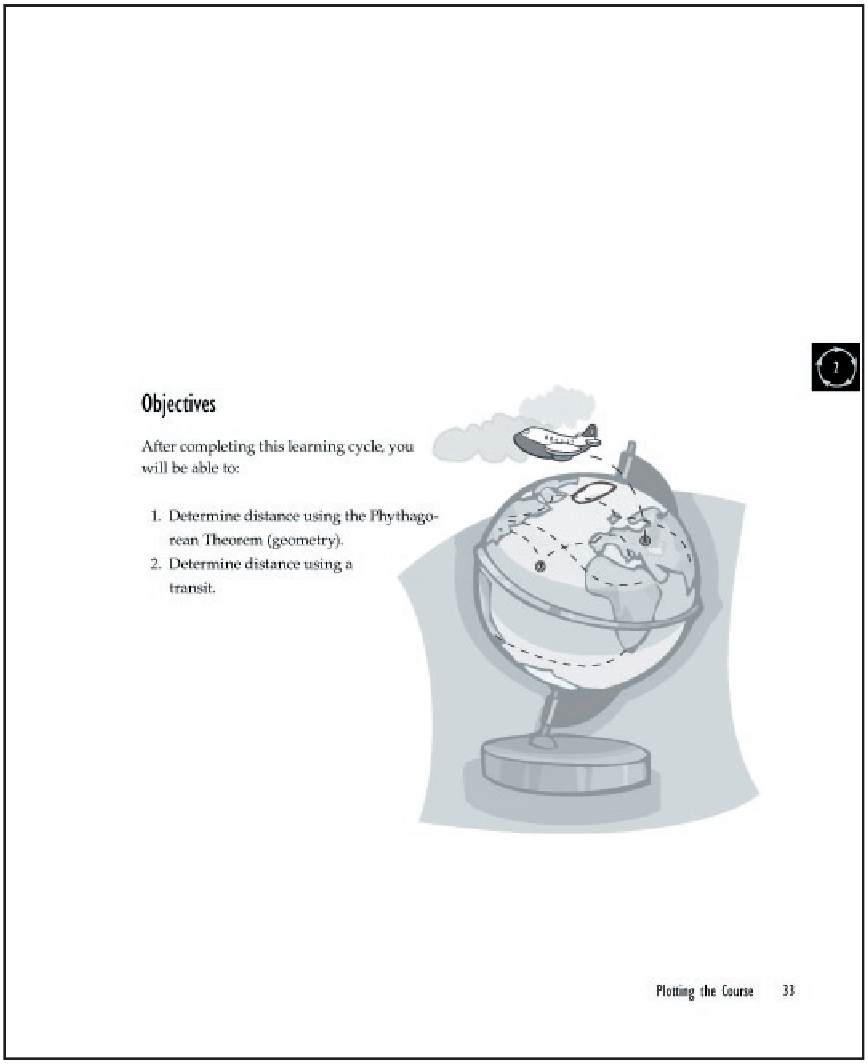
MOST OF US HAVE BEEN ON A TRIP and have taken a wrong turn, only to become lost. What tools or techniques did you use to get yourself back on the correct path? Perhaps you used a map. Maybe you looked for street signs, landmarks, or used a compass. However, what if you found yourself lost in a foreign land without maps or street signs to help guide you? How would you determine distance and direction, so you could avoid walking around in circles?

During this learning cycle, you will be exploring how simple systems can be used to monitor distance and direction. In the first *Exploration* activity, you will be determining distance using mathematic equations. In the second activity, you will be measuring distance by constructing a transit. After completing this learning cycle, you will apply what you have learned about distance and direction to your *Primary Challenge* solution.

32 Project ProBase • Transportation Technologies

Transportation Technologies
Learning Cycle Two Concept Map




Objectives

After completing this learning cycle, you will be able to:

1. Determine distance using the Phythagorean Theorem (geometry).
2. Determine distance using a transit.

Plotting the Course 33

Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Determine distance using the Pythagorean Theorem (geometry).

Essential Question 9b: How are technologies used to control devices or systems and provide information to humans?

4. Determine distance using a transit.

Essential Question 4a: What are the systems and subsystems involved in the various contexts of technology?

Equipment and Materials

Based on a class of 28 students:

(7) Photocopies of protractor

(1) 50' Tape Measure

(1) Laser measuring device with visible laser beam and a range of 60 feet

Glue guns and glue

1/4" Plywood

Band or scroll saw

1/2" PVC pipe

Power drill and drill bits

Screws and washers

Facility Requirements

Exploration I and II work best in a classroom with large tables. The *Engagement* activity works best when you can make use of the largest possible area outside of your building. If possible, use the football field, tennis courts, soccer field, etc.

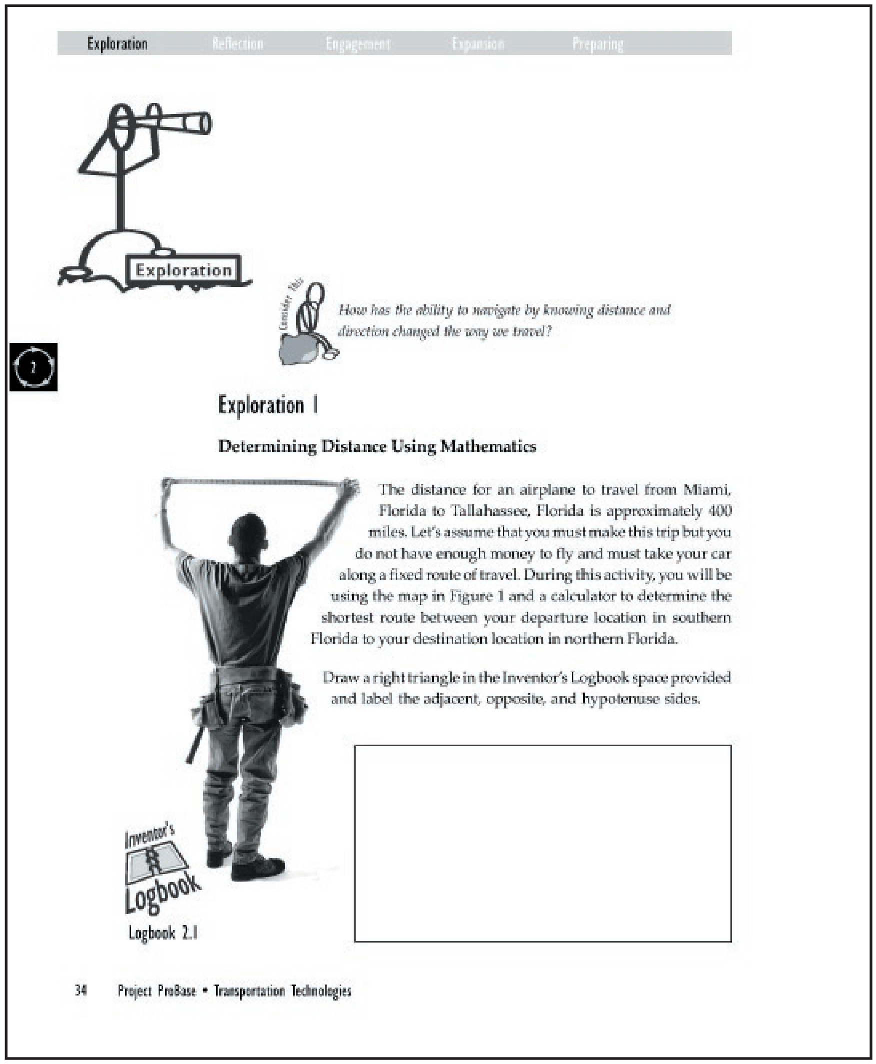
Exploration I

Determining Distance Using Mathematics

This activity requires students to have a basic understanding of the Pythagorean Theorem:

$$(a^2 + b^2 = c^2)$$

Students should be able to locate the correct formula for determining the length of a side of a right triangle. Given a map of the State of Florida (p. 35 in the Student Guide), students must determine which route will enable them to travel the fewest number of miles and still reach the appointed destination.


Exploration Reflection Engagement Expansion Preparing

Consider This — *How has the ability to navigate by knowing distance and direction changed the way we travel?*

Exploration I

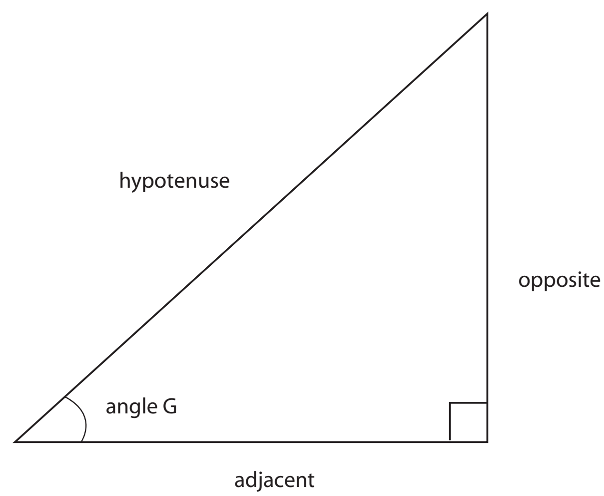
Determining Distance Using Mathematics

The distance for an airplane to travel from Miami, Florida to Tallahassee, Florida is approximately 400 miles. Let's assume that you must make this trip but you do not have enough money to fly and must take your car along a fixed route of travel. During this activity, you will be using the map in Figure 1 and a calculator to determine the shortest route between your departure location in southern Florida to your destination location in northern Florida.

Draw a right triangle in the Inventor's Logbook space provided and label the adjacent, opposite, and hypotenuse sides.

Logbook 2.1

Estimated Number of 50-minute class periods: **6**



Logbook 2.1 entry: triangle labels

Suggested Daily Outline

Day One	Day Two	Day Three
Introduction, *Exploration I* *Reflection I*	*Exploration II*	*Exploration II* *Reflection II*
Day Four	**Day Five**	**Day Six**
Engagement	*Engagement*	*Engagement* *Preparing for the Challenge*

Using the Pythagorean Theorem and other trigonometry relationships, determine which route is the longest, according to the map in Figure 1. Record your data for each route in Table 1.

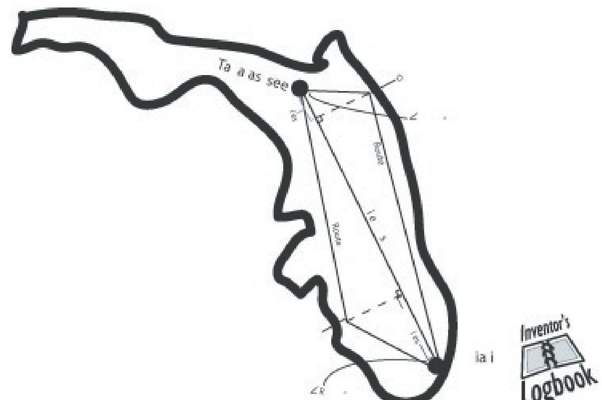


Figure 1.

Logbook 2.2

Table 1.
Distances for Route One and Route Two

Route	Length of Line Segments (miles)				Degree for Angle Q	Degree for Angle R	Total Distance Traveled
	A, C	C, B	A, D	D, B			
1			NA	NA			
2	NA	NA					

Teaching Tips

Students are also required to locate the formula for determining the length of the sides of a right triangle. They need to use this information to determine the length of the opposite side of each right triangle (this is the dashed line on the map). Knowing two sides allows the students to use the Pythagorean Theorem to determine the actual distance traveled (hypotenuse).

Depending on the students' knowledge of trigonometry, they may choose other methods to solve this problem. However, one of the most efficient ways to approach this problem is described on the following two pages. The correct answers are also provided.

Teaching Tips

You may want to collaborate with a mathematics teacher for this activity. Students will be more successful if they understand the parts of a right triangle. Students are asked to draw a right triangle in the Inventor's Logbook space provided in their text and label the adjacent, opposite, and hypotenuse sides.

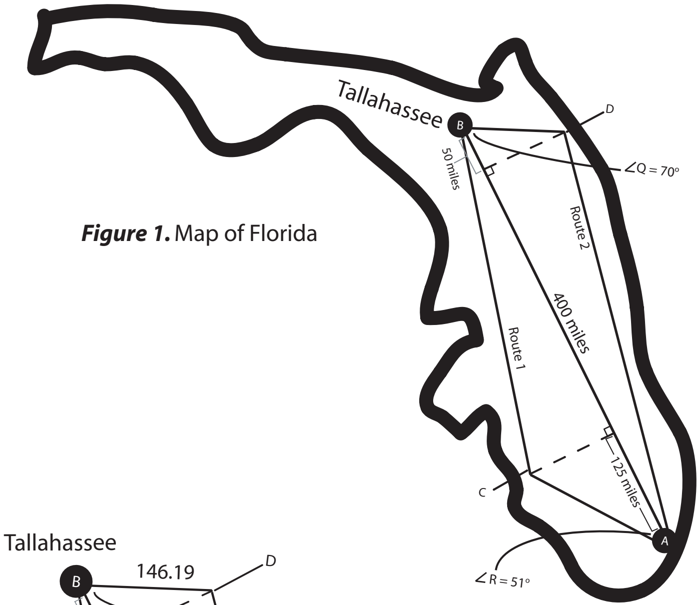


Figure 1. Map of Florida

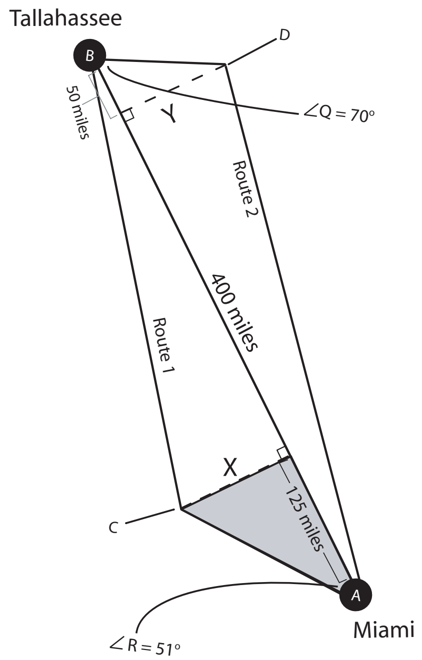


Figure 1a. Tangent of angle R

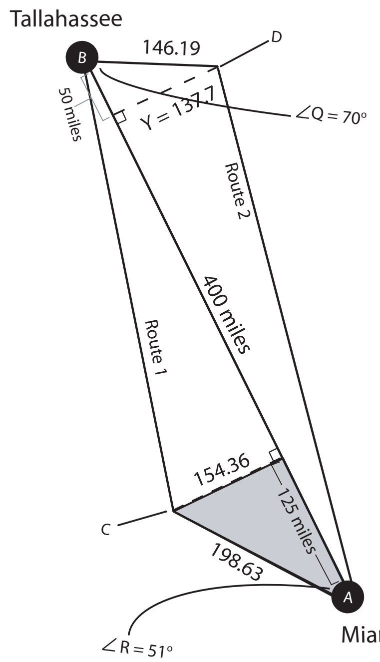


Figure 1b. Length of segment AC

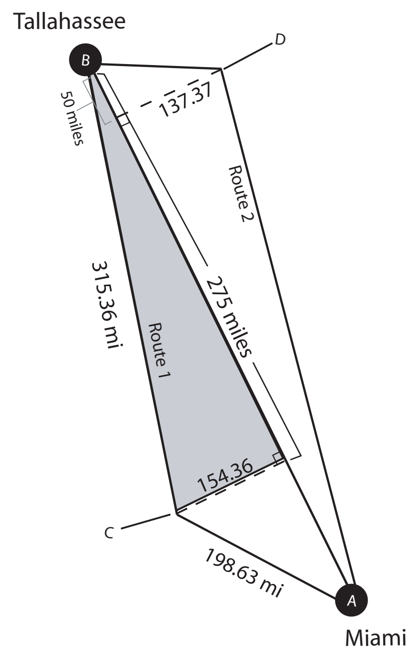


Figure 1c. Length of segment CB

Table 2.
Distances for Route One and Route Two

<table>
<tr><th rowspan="2">Route</th><th colspan="4">Length of Line Segments (miles)</th><th rowspan="2">Degree for Angle Q</th><th rowspan="2">Degree for Angle R</th><th rowspan="2">Total Distance Traveled</th></tr>
<tr><th>A, C</th><th>C, B</th><th>A, D</th><th>D, B</th></tr>
<tr><td>1</td><td>198.63</td><td>315.36</td><td>NA</td><td>NA</td><td rowspan="2">70</td><td rowspan="2">51</td><td>513.99</td></tr>
<tr><td>2</td><td>NA</td><td>NA</td><td>375.99</td><td>146.19</td><td>434.24</td></tr>
</table>

tan(of angle R or Q) =
length of the opposite side / length of the adjacent side

Solving for Route 1

(use Figure 1a)

Adjacent side = 125 miles
Angle R = 51^0
tan (51^0) = 1.2349
Therefore: 1.2349 = opposite side (X) / 125
1.2349 x 125 = X
154.36 = X

(use Figure 1b)

Now that we know the length of the opposite and adjacent sides we can use the Pythagorean Theorem ($a^2 + b^2 = c^2$) to find the length of line segment AC.
$125^2 + 154.36^2 = c^2$
$15625 + 23827.01 = c^2$
$39452.67 = c^2$
$\sqrt{\ }$ = 198.63 miles = c (segment AC)

(use Figure 1c)

A similar process is followed to determine the length of line segment C, B. To find the length of the adjacent side one must subtract 125 miles from 400 miles. 275 miles is the length of the adjacent side used in the Pythagorean Theorem to solve the hypotenuse C, B.
($a^2 + b^2 = c^2$)
$275^2 + 154.36^2 = c^2$
$75625 + 23827.01 = c^2$
$9945.01 = c^2$
$\sqrt{\ }$ = 315.36 miles = c (segment CB)

The final step is to add the length of both line segments together to find the total distance of Route 1.
198.63 + 315.36 = **513.99 miles**

Solving for Route 2

(use the Figures 1a-c, but solve for Route 2)

Students should find the distance of Route 2 using a similar process as finding that for Route 1.

Adjacent side = 50 miles
Angle Q = 70^0
tan (70^0) = 2.7475
Therefore: 2.7475 = opposite side (Y) / 50
Y = 137.37 miles

The length of line segment BD
($a^2 + b^2 = c^2$)
$137.37^2 + 50^2 = c^2$
$\sqrt{\ }$ = 146.19 miles = c (segment BD)

The length of line segment DA
($a^2 + b^2 = c^2$)
$137.37^2 + 350^2 = c^2$
$18870.52 + 122500 = c^2$
$141370.52 = c^2$
$\sqrt{\ }$ = 375.99 miles = c (segment DA)

The total distance of Route 2 = (146.19 + 375.99)= **522.18 miles**

Therefore, the shortest route between Tallahassee and Miami is Route 1 @ 513.99 miles.

A black line master of the map can be found in the Appendix.

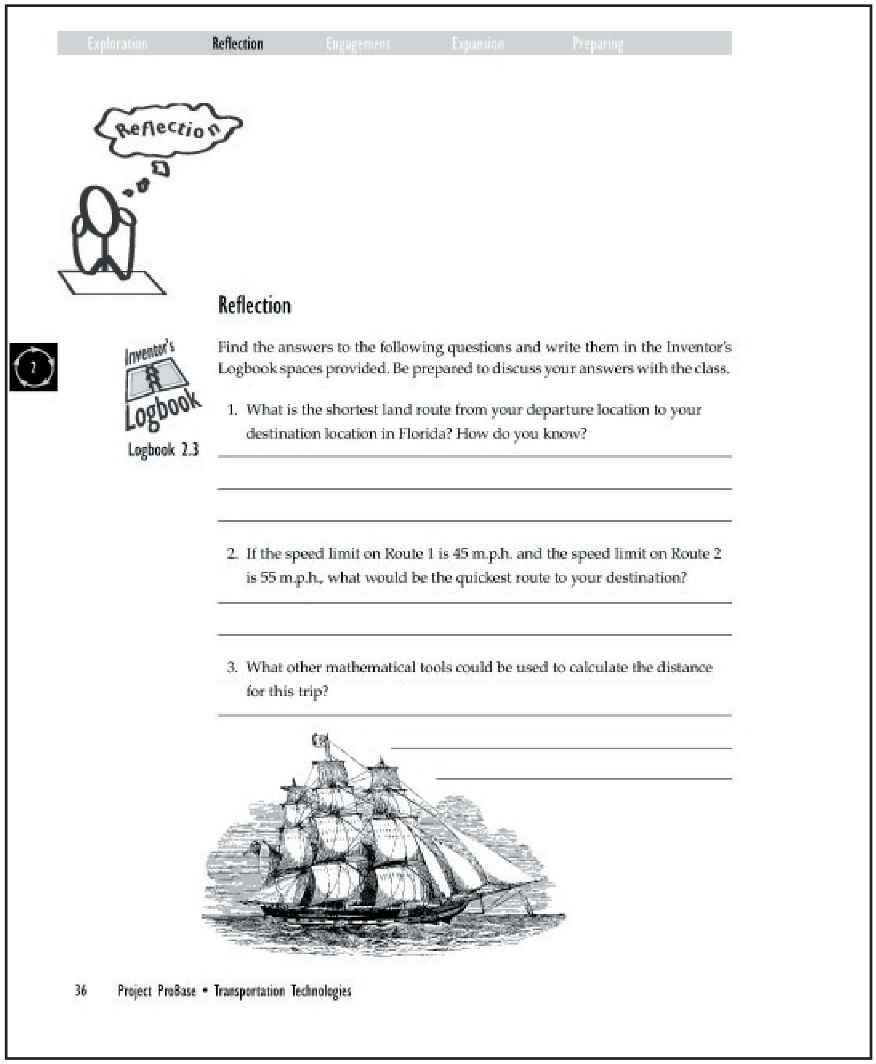
Reflection

Students should record the answers to the following questions in the Inventor's Logbook spaces provided.

1. What is the shortest land route from your departure location to your destination location in Florida? How do you know?
   The shortest route between Tallahassee and Miami is Route 1 @ 513.99 miles.

2. If the speed limit on Route 1 is 45 mph and the speed limit on Route 2 is 55 mph, what would be the quickest route?
   Route 1 =
   513.99 miles / 45 mph =
   11.42 hrs
   Route 2 =
   522.18 miles / 55 mph =
   9.49 hrs

3. What other mathematical methods can you use to calculate the distance?
   Using the longitude and latitude coordinates, you can also measure distance.



Exploration Reflection Engagement Expansion Preparing

Reflection

Inventor's Logbook

Logbook 2.3

Reflection

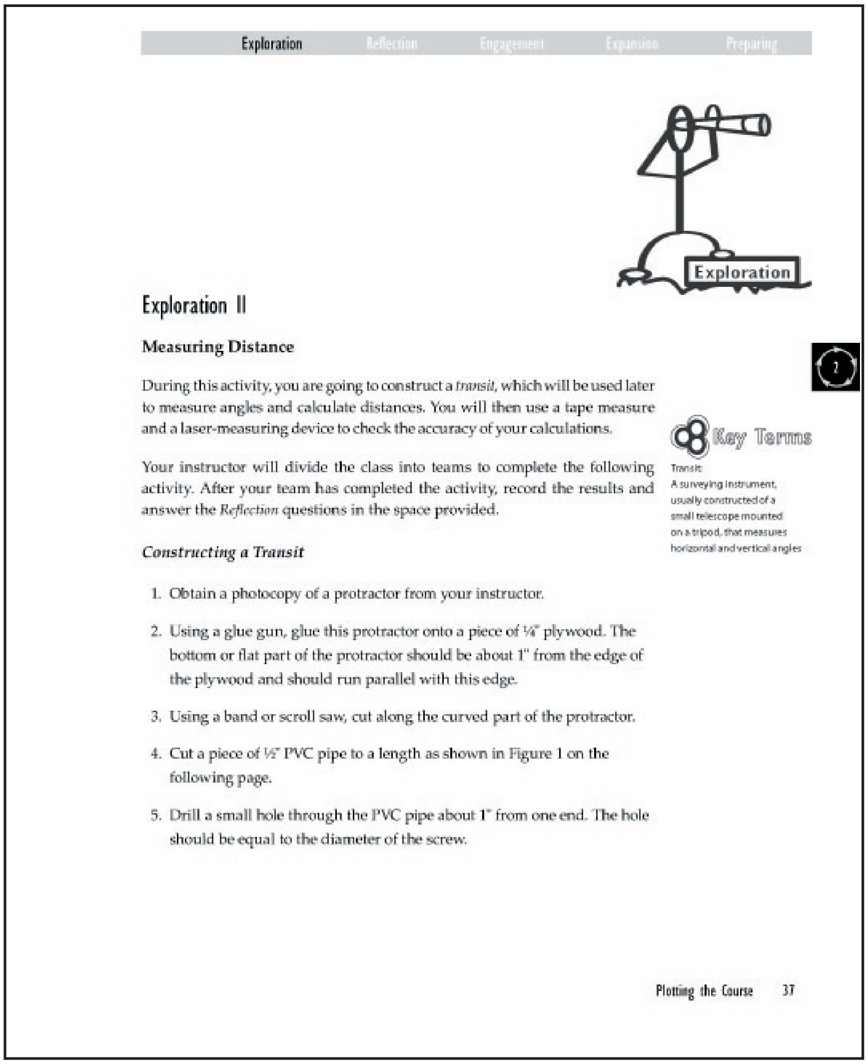
Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Be prepared to discuss your answers with the class.

1. What is the shortest land route from your departure location to your destination location in Florida? How do you know?

2. If the speed limit on Route 1 is 45 m.p.h. and the speed limit on Route 2 is 55 m.p.h., what would be the quickest route to your destination?

3. What other mathematical tools could be used to calculate the distance for this trip?

36 Project ProBase • Transportation Technologies



Exploration Reflection Engagement Expansion Preparing

Exploration II

Measuring Distance

During this activity, you are going to construct a *transit*, which will be used later to measure angles and calculate distances. You will then use a tape measure and a laser-measuring device to check the accuracy of your calculations.

Your instructor will divide the class into teams to complete the following activity. After your team has completed the activity, record the results and answer the *Reflection* questions in the space provided.

Key Terms

Transit:
A surveying instrument, usually constructed of a small telescope mounted on a tripod, that measures horizontal and vertical angles

Constructing a Transit

1. Obtain a photocopy of a protractor from your instructor.
2. Using a glue gun, glue this protractor onto a piece of ¼" plywood. The bottom or flat part of the protractor should be about 1" from the edge of the plywood and should run parallel with this edge.
3. Using a band or scroll saw, cut along the curved part of the protractor.
4. Cut a piece of ½" PVC pipe to a length as shown in Figure 1 on the following page.
5. Drill a small hole through the PVC pipe about 1" from one end. The hole should be equal to the diameter of the screw.

Plotting the Course 37

Exploration II

The purpose for this *Exploration* is for students to construct a measuring device that will be used during the *Engagement* activity. A transit is a device that uses the mathematical concepts explored on paper (during the first *Exploration*) and applies them to real situations.

Place your students in teams of three or four to construct their devices. These same teams will complete the *Engagement* activity.

Teaching Tips

You should encourage the students to first research transits so they understand how they work before they begin constructing their devices. If they do not construct their devices correctly, the measurements they take during the *Engagement* activity will be incorrect.

2

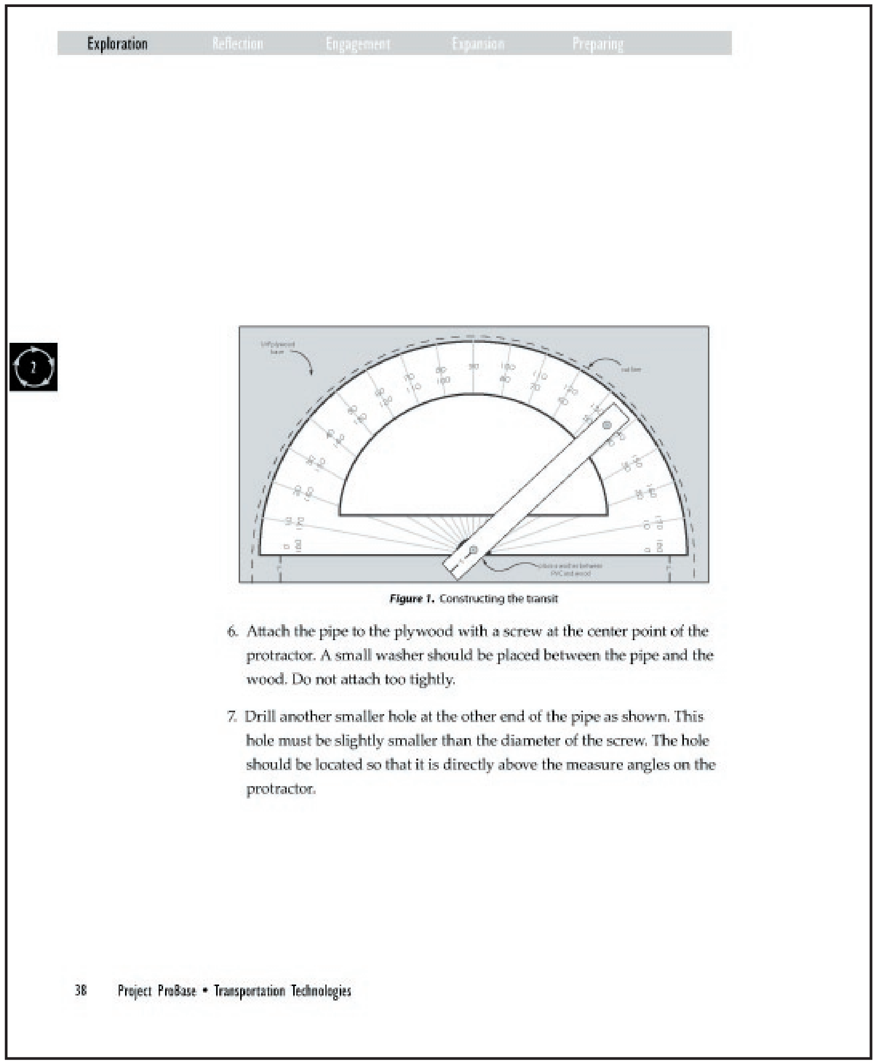


Figure 1. Constructing the transit

6. Attach the pipe to the plywood with a screw at the center point of the protractor. A small washer should be placed between the pipe and the wood. Do not attach too tightly.

7. Drill another smaller hole at the other end of the pipe as shown. This hole must be slightly smaller than the diameter of the screw. The hole should be located so that it is directly above the measure angles on the protractor.

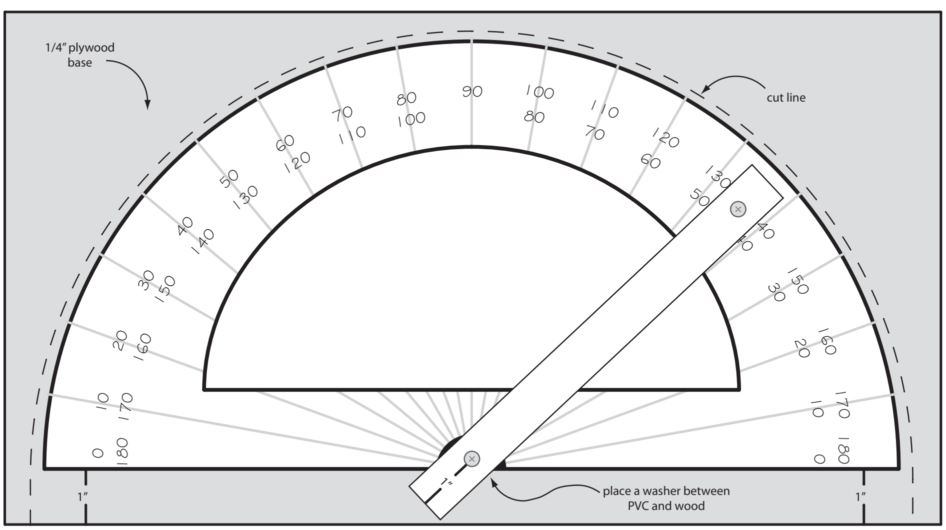
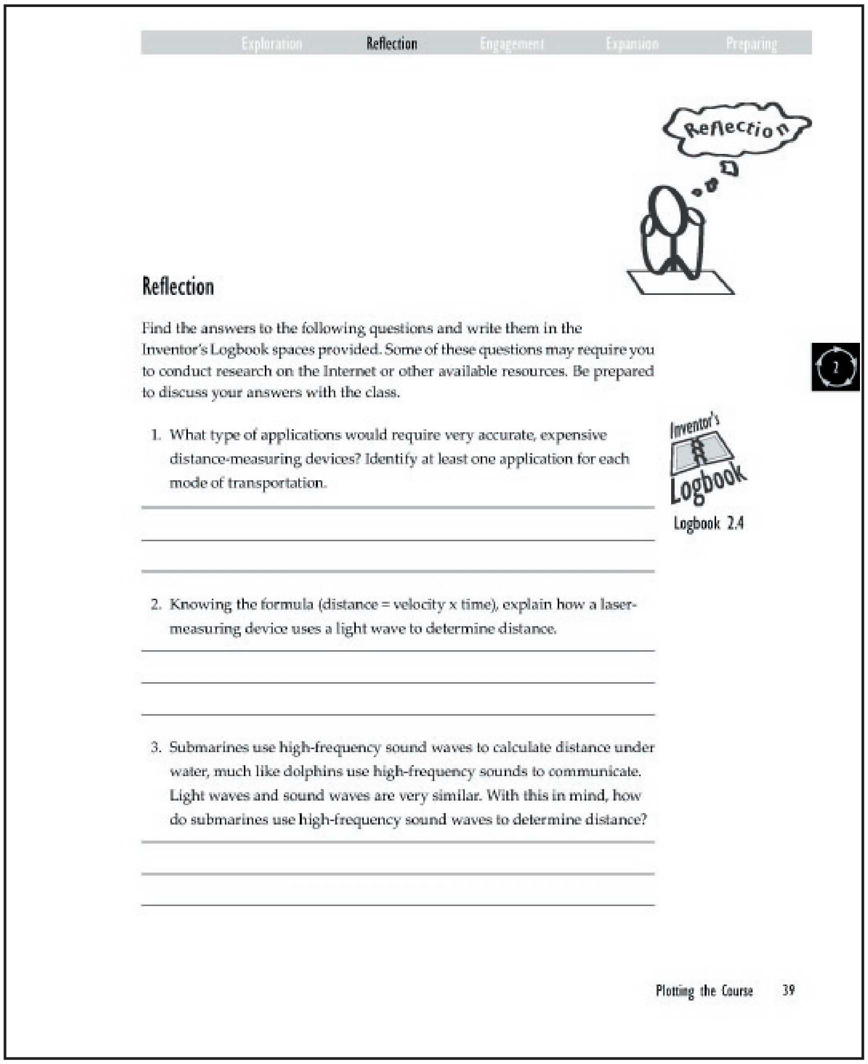


Figure 1. Constructing the transit



Exploration Reflection Engagement Expansion Preparing

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Some of these questions may require you to conduct research on the Internet or other available resources. Be prepared to discuss your answers with the class.

Inventor's Logbook

Logbook 2.4

1. What type of applications would require very accurate, expensive distance-measuring devices? Identify at least one application for each mode of transportation.

2. Knowing the formula (distance = velocity x time), explain how a laser-measuring device uses a light wave to determine distance.

3. Submarines use high-frequency sound waves to calculate distance under water, much like dolphins use high-frequency sounds to communicate. Light waves and sound waves are very similar. With this in mind, how do submarines use high-frequency sound waves to determine distance?

Plotting the Course 39

Reflection

1. What type of applications would require very accurate, expensive distance-measuring devices? Identify at least one application for each mode of transportation.
Land: Mobility of Blind and Elderly People Interacting with Computers (MoBIC) uses a route planning system. Air: Aircraft use Distance Measuring Equipment (DME), which is a transponder-based radio navigation technology that measures distance by timing the propagation delay of UHF radio signals. Water: The USS Cape St. George, a guided missile cruiser, uses Electronic Charting Display and Information System-Navy (ECDIS-N) with the National Geospatial-Intelligence Agency's Digital Nautical Chart (DNC). Space: The Hubble Space Telescope measures distance in space.

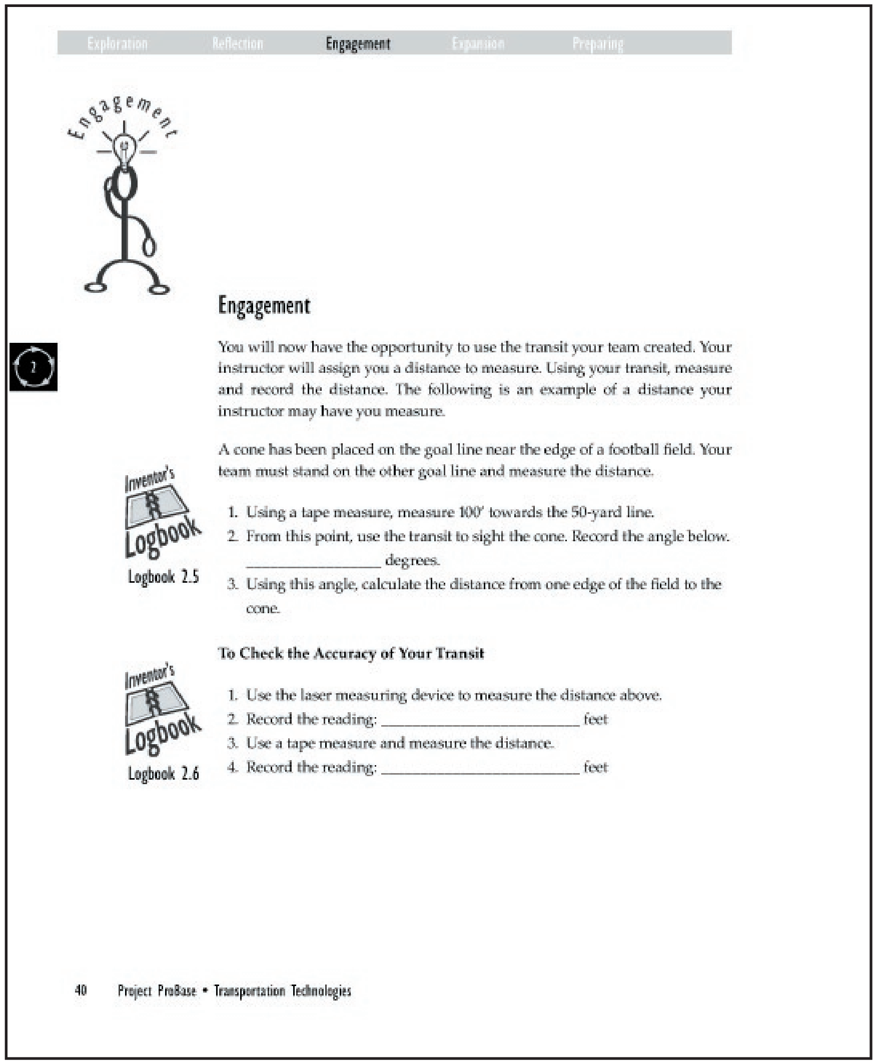
2. Knowing the formula (distance = velocity x time), explain how a laser-measuring device uses a light wave to determine distance.
Light travels in a straight line, which makes it feasible to use different geometric methods for measuring distance. Light propagates through space at the speed of light, which is measured at 299,792,458 meters per second.

3. Submarines use high-frequency sound waves to calculate distance under water, much like dolphins use high-frequency sounds to communicate. Light waves and sound waves are very similar. With this in mind, how might a submarine use high frequency sound waves to determine distance?
Sonar determines distance by measuring the time taken for a sound wave to travel from the transmitter, reflect from an object, and travel to the receiver.

2

Engagement

Working in the same teams, students will use the transits they created. This activity will need to be completed outdoors at the football field, soccer field, tennis courts, etc. You will need to provide the teams with distances to measure. An example is provided in the student guide. You may decide to use different measurements as you see fit. Students will need to measure the distances using the transit and a tape measure and record their observations. Students will then need to measure the same distance with a tape-measure and a laser measuring device to check the accuracy of their device.



Exploration Reflection Engagement Expansion Preparing

Engagement

Engagement

You will now have the opportunity to use the transit your team created. Your instructor will assign you a distance to measure. Using your transit, measure and record the distance. The following is an example of a distance your instructor may have you measure.

A cone has been placed on the goal line near the edge of a football field. Your team must stand on the other goal line and measure the distance.

Inventor's Logbook
Logbook 2.5

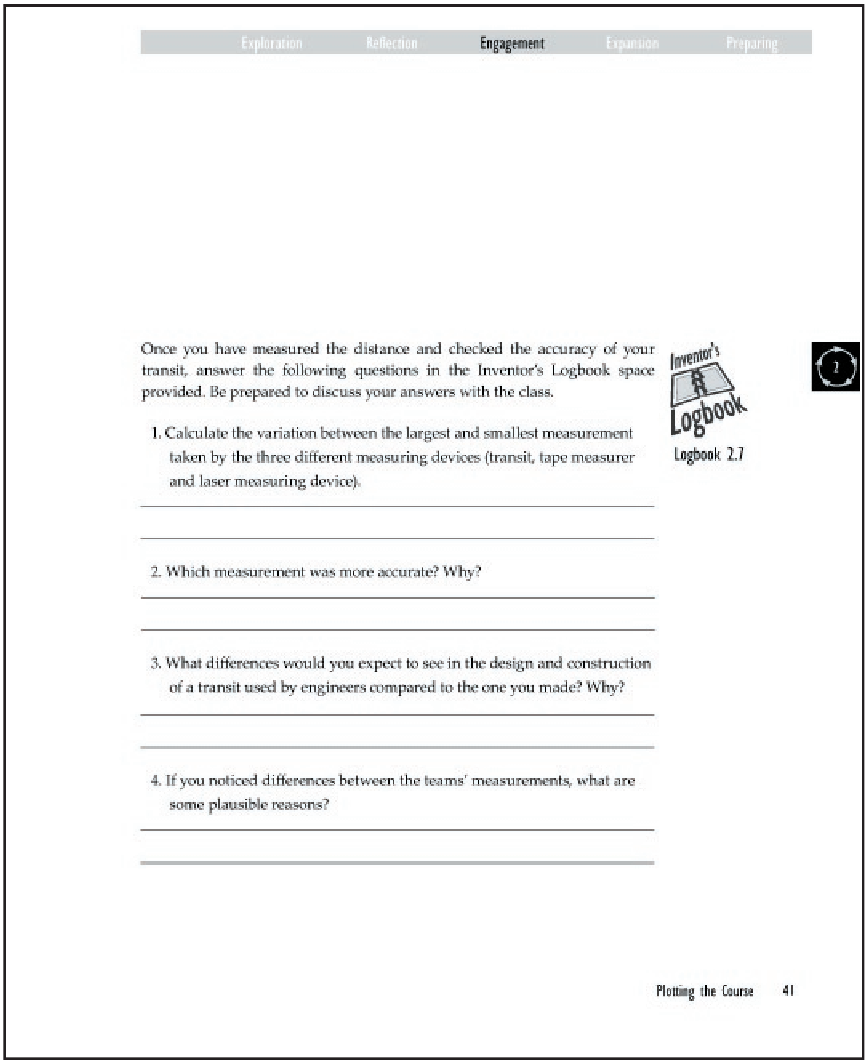
1. Using a tape measure, measure 100' towards the 50-yard line.
2. From this point, use the transit to sight the cone. Record the angle below. ________________ degrees.
3. Using this angle, calculate the distance from one edge of the field to the cone.

To Check the Accuracy of Your Transit

Inventor's Logbook
Logbook 2.6

1. Use the laser measuring device to measure the distance above.
2. Record the reading: ________________________ feet
3. Use a tape measure and measure the distance.
4. Record the reading: ________________________ feet

40 Project ProBase • Transportation Technologies


Exploration Reflection Engagement Expansion Preparing

Once you have measured the distance and checked the accuracy of your transit, answer the following questions in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

Inventor's Logbook

Logbook 2.7

1. Calculate the variation between the largest and smallest measurement taken by the three different measuring devices (transit, tape measurer and laser measuring device).

2. Which measurement was more accurate? Why?

3. What differences would you expect to see in the design and construction of a transit used by engineers compared to the one you made? Why?

4. If you noticed differences between the teams' measurements, what are some plausible reasons?

Plotting the Course 41

Once all of the teams have completed the activity, students should answer the questions below.

1. Calculate the variation between the largest and smallest measurement taken by the three different measuring devices (transit, tape measurer, and laser measuring device).
   Answers will vary.

2. Which measurement was more accurate? Why?
   Answers may vary. The most accurate measurement may depend on the type of the device and the method used to calculate the distance.

3. What differences would you expect to see in the design and construction of a transit used by engineers compared to the one you made? Why?
   Students may need to conduct research on transits used by engineers to determine the differences. Commercial transits have a high rate of accuracy because of the way they are constructed.

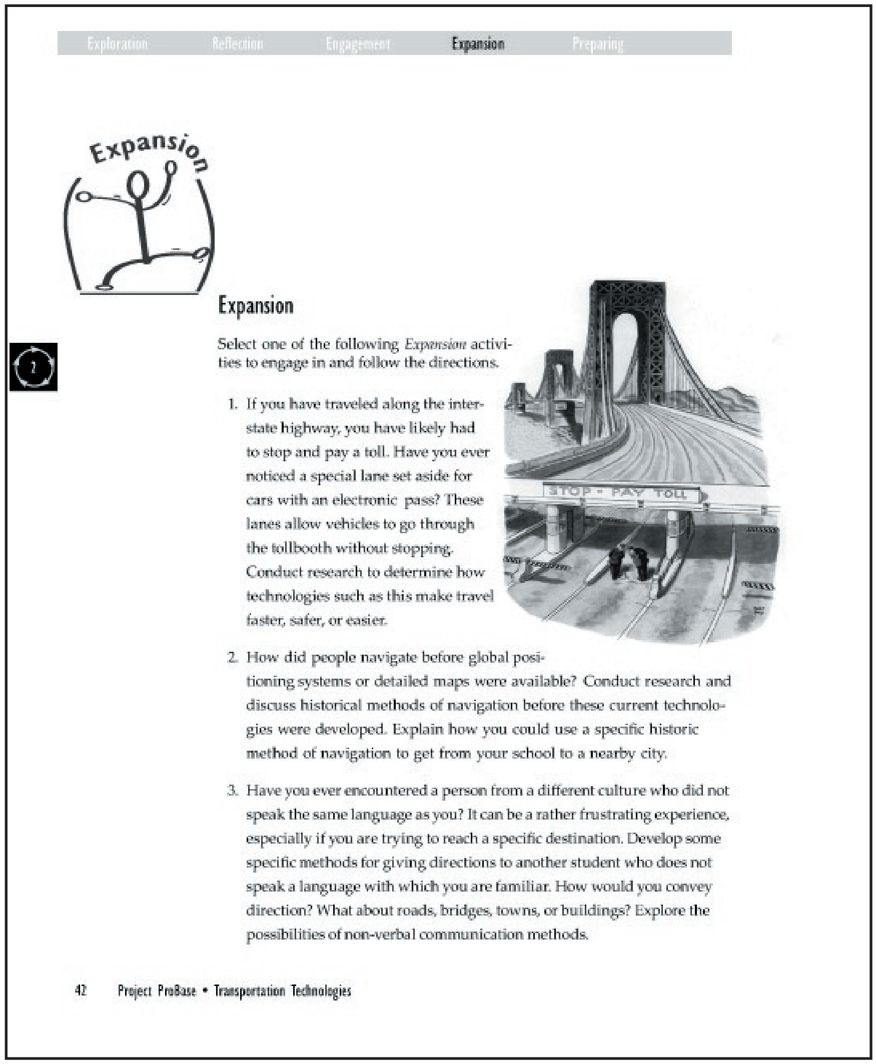
4. If you noticed differences between the teams' measurements, what are some plausible reasons for measuring errors?
   Answers may vary. Measuring errors may be attributed to faulty construction and errors in calculation.

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into concepts explored in this learning cycle.

1. If you have traveled along the interstate highway, you have likely had to stop and pay a toll. Have you ever noticed a special lane set aside for cars with an electronic pass? These lanes allow vehicles to go through the tollbooth without stopping. Conduct research to determine how technologies such as this make travel faster, safer, or easier.

2. How did people navigate before global positioning systems (GPS) or detailed maps were available? Conduct research and discuss historical methods of navigation before these current technologies were developed. Explain how you could use a specific historic method of navigation to get from your school to a nearby city.



Exploration Reflection Engagement **Expansion** Preparing

Expansion

Expansion

Select one of the following *Expansion* activities to engage in and follow the directions.

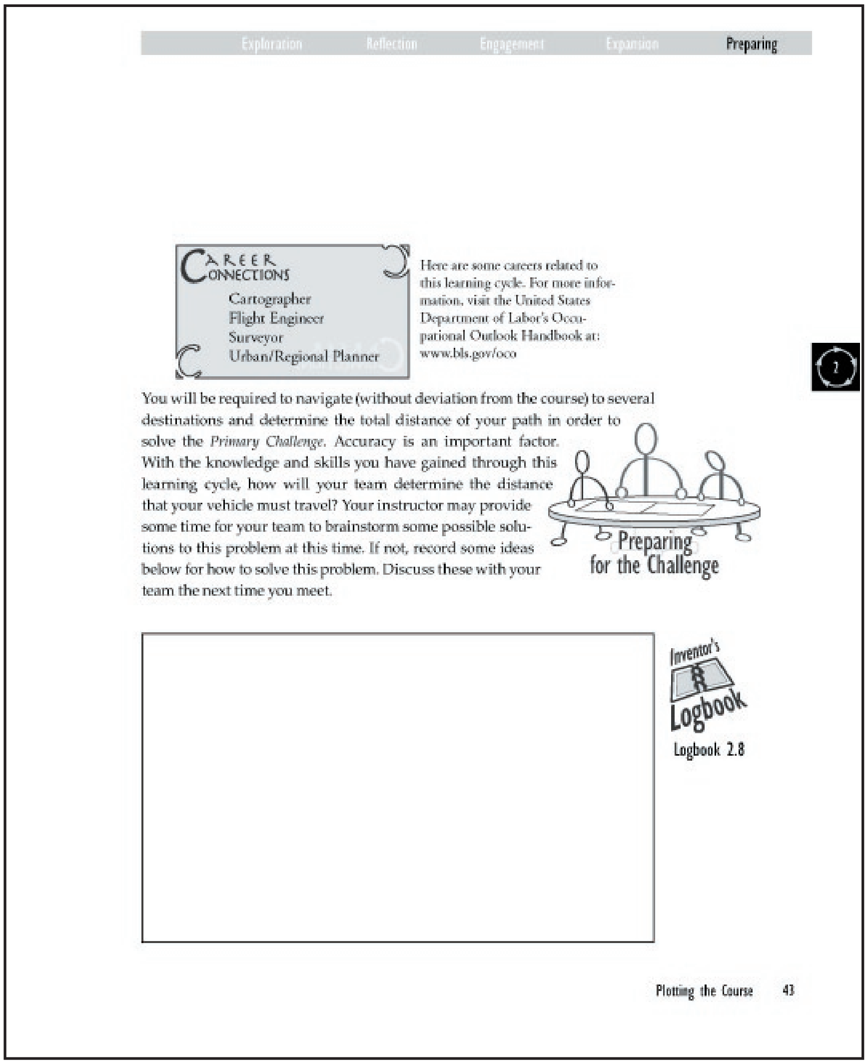
1. If you have traveled along the interstate highway, you have likely had to stop and pay a toll. Have you ever noticed a special lane set aside for cars with an electronic pass? These lanes allow vehicles to go through the tollbooth without stopping. Conduct research to determine how technologies such as this make travel faster, safer, or easier.

2. How did people navigate before global positioning systems or detailed maps were available? Conduct research and discuss historical methods of navigation before these current technologies were developed. Explain how you could use a specific historic method of navigation to get from your school to a nearby city.

3. Have you ever encountered a person from a different culture who did not speak the same language as you? It can be a rather frustrating experience, especially if you are trying to reach a specific destination. Develop some specific methods for giving directions to another student who does not speak a language with which you are familiar. How would you convey direction? What about roads, bridges, towns, or buildings? Explore the possibilities of non-verbal communication methods.

42 Project ProBase • Transportation Technologies

3. Have you ever encountered a person from a different culture who did not speak the same language as you? It can be a rather frustrating experience, especially if you are trying to reach a specific destination. Develop some specific methods for giving directions to another student who does not speak a language with which you are familiar. How would you convey the idea of direction? What about roads, bridges, towns, or buildings? Explore the possibilities of nonverbal communication methods.


Exploration Reflection Engagement Expansion **Preparing**

CAREER CONNECTIONS

- Cartographer
- Flight Engineer
- Surveyor
- Urban/Regional Planner

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

You will be required to navigate (without deviation from the course) to several destinations and determine the total distance of your path in order to solve the *Primary Challenge*. Accuracy is an important factor. With the knowledge and skills you have gained through this learning cycle, how will your team determine the distance that your vehicle must travel? Your instructor may provide some time for your team to brainstorm some possible solutions to this problem at this time. If not, record some ideas below for how to solve this problem. Discuss these with your team the next time you meet.

Preparing for the Challenge

Inventor's Logbook

Logbook 2.8

Plotting the Course 43

Preparing for the Challenge

Students should develop a navigation system from these activities that can be incorporated into their solution of the *Primary Challenge* to help ensure navigation of the course without deviation. Time spent brainstorming plausible solutions in their *Primary Challenge* teams is optional here.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

Plotting the Course

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Measuring devices	Demonstrated a complete understanding of the proper use of measuring devices.	Demonstrated a considerable understanding of the proper use of measuring devices.	Demonstrated a basic understanding of the proper use of measuring devices.	Demonstrated limited or no understanding of the proper use of measuring devices.	
Mathematical computation	Demonstrated a complete understanding of the proper mathematical formulas.	Demonstrated a considerable understanding of the proper mathematical formulas.	Demonstrated a basic understanding of the proper mathematical formulas.	Demonstrated limited or no understanding of the mathematical formulas.	
Inventor's Logbook Trade-offs	Fully identifies and comprehends the trade-offs considered while designing.	Identifies and comprehends most trade-offs considered while designing.	Identifies and comprehends some trade-offs considered while designing.	Does not identify or comprehend trade-offs considered while designing.	
				Total Points	

Learning Cycle Three

3

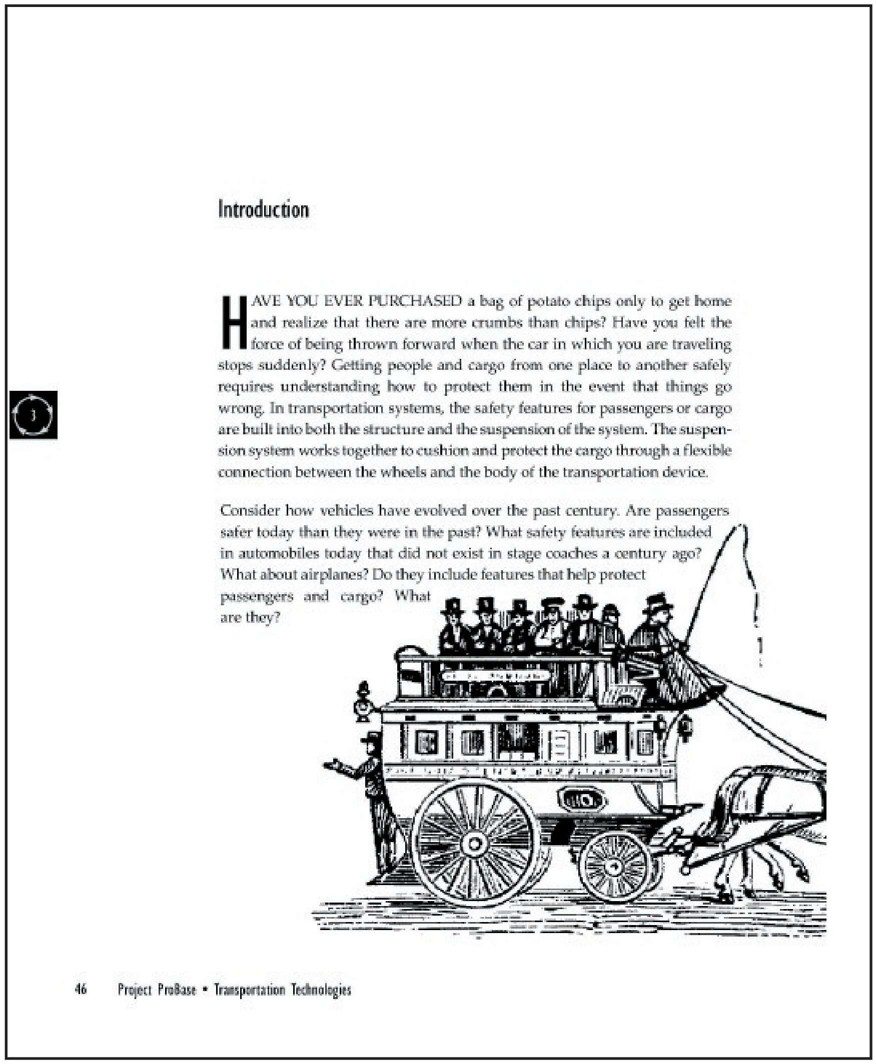
Safety First

Safety First

Introduction

The goal of this learning cycle is for the students to understand how structure and support systems are related within a transportation device. Both systems affect passenger and cargo safety and work together to ensure safe transportation.

Through the *Exploration* activities, students research different structural safety systems and prepare a presentation for the class. They also explore the concept of suspension systems by constructing shock absorbers of several different types and testing them over rough terrain using a wagon. In the *Engagement* activity, students learn how structure and suspension systems are directly related to one another by safely transporting a Pringles® potato chip along a guided path. These activities will help prepare your students for the *Primary Challenge* as they develop structure and suspension systems to transport objects safely from one point to another.



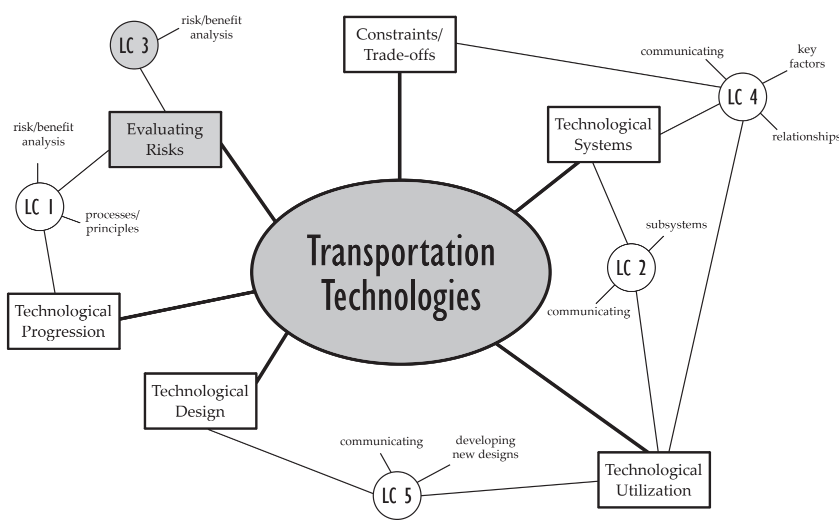
Introduction

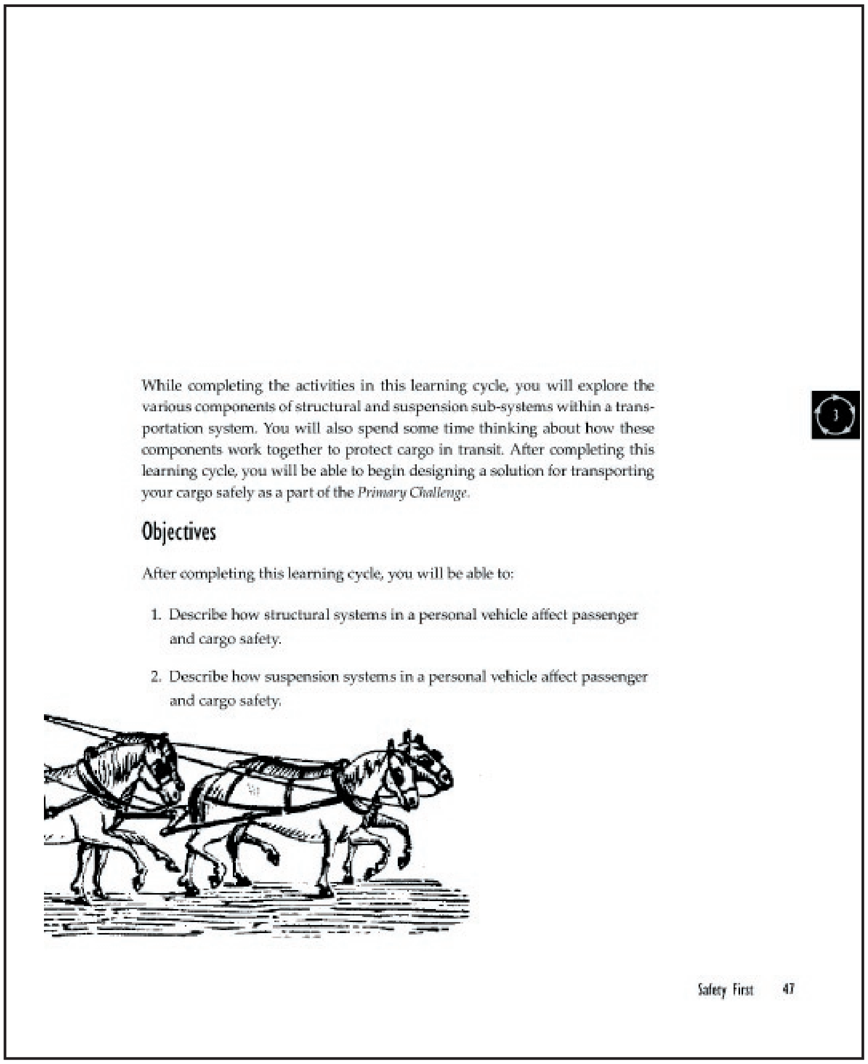
HAVE YOU EVER PURCHASED a bag of potato chips only to get home and realize that there are more crumbs than chips? Have you felt the force of being thrown forward when the car in which you are traveling stops suddenly? Getting people and cargo from one place to another safely requires understanding how to protect them in the event that things go wrong. In transportation systems, the safety features for passengers or cargo are built into both the structure and the suspension of the system. The suspension system works together to cushion and protect the cargo through a flexible connection between the wheels and the body of the transportation device.

Consider how vehicles have evolved over the past century. Are passengers safer today than they were in the past? What safety features are included in automobiles today that did not exist in stage coaches a century ago? What about airplanes? Do they include features that help protect passengers and cargo? What are they?

46 Project ProBase • Transportation Technologies

Transportation Technologies
Learning Cycle Three Concept Map





While completing the activities in this learning cycle, you will explore the various components of structural and suspension sub-systems within a transportation system. You will also spend some time thinking about how these components work together to protect cargo in transit. After completing this learning cycle, you will be able to begin designing a solution for transporting your cargo safely as a part of the *Primary Challenge*.

Objectives

After completing this learning cycle, you will be able to:

1. Describe how structural systems in a personal vehicle affect passenger and cargo safety.
2. Describe how suspension systems in a personal vehicle affect passenger and cargo safety.

Safety First 47

Facility Requirements

Students will need to use computers with Internet access for researching the structural safety components in *Exploration I.*

Because *Exploration II* requires the transportation of water, a non-carpeted area for the construction and transportation of the cargo is ideal.

The facility for launching solutions to the *Engagement* activity needs to accommodate a means of securing the launcher and running the track approximately 40 feet to attach to a wall. This facility should also be large enough to allow the spectators to stand a safe distance from the track.

Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Describe how structural systems in a personal vehicle affect passenger and cargo safety.
Essential Question 8a: How does the risk/benefit analysis aid the designer in addressing potential harmful effects prior to development?

2. Describe how suspension systems in a personal vehicle affect passenger and cargo safety.
Essential Question 8a: How does the risk/benefit analysis aid the designer in addressing potential harmful effects prior to development?

Equipment and Materials

Based on a class of 28 students:

Exploration

**You will need to nail the rubber stoppers to the blocks of wood before students begin the second *Exploration* activity. Make sure that the larger stoppers fit inside the fluorescent light shields and the smaller stoppers fit inside the drainpipe before purchasing. If not, make adjustments. Hot glue can be used to make the stoppers fit snugly.

3

Estimated Number of 50-minute class periods: **7**

Exploration materials:

(21) Blocks of wood (3" X 3" X 1")

(21) Rubber stoppers, #8

(5) 48" clear plastic tubes used to protect fluorescent lights

(50) Round strong magnets with an approximate 1" diameter

(7) Springs (loose tension) approximately 3" X .75"

(7) Golf tees

(7) Medium balloons

(5-7) Hot glue guns & glue sticks

(21) Plastic drainpipes (1.5" X 6")

(21) Rubber stoppers, #7

(2) Small toy wagons

Suggested Daily Outline

Day One	Day Two	Day Three	
Introduction, *Exploration I*	*Exploration I Reflection I*	*Exploration II*	
Day Four	Day Five	Day Six	Day Seven
Exploration II Reflection II	*Engagement*	*Engagement*	*Engagement, Preparing for the Challenge*

Engagement materials

**You will need to construct a firing device for the CO_2 powered vehicle for the *Engagement* activity. Follow the diagram provided in the *Engagement* section to build the device and use the following materials:

CO 2 firing pin set (Pitsco # 11341) **or**
1 spring-loaded center punch

Large gate hinge (may use a hammer)

50' Nylon fishing line (at least 50 lb. Test)

(2) Eye screws

Wood block (1" X 6" X 48")

Student materials:

(7) Mathematical analysis sheets (located in the Appendix)

(7) Pieces of cardboard (1' x1')

(7) Styrofoam blocks (3" X 3" X 3")

(7) Foam peanuts

(70) Wood craft sticks

(28) Straws

(14) Eye hooks

(7) 12 oz. paper cups

(7) Index cards

(14) Rubber bands

(7) CO 2 cartridges (4 grams) Optional source: Pitsco #W53338

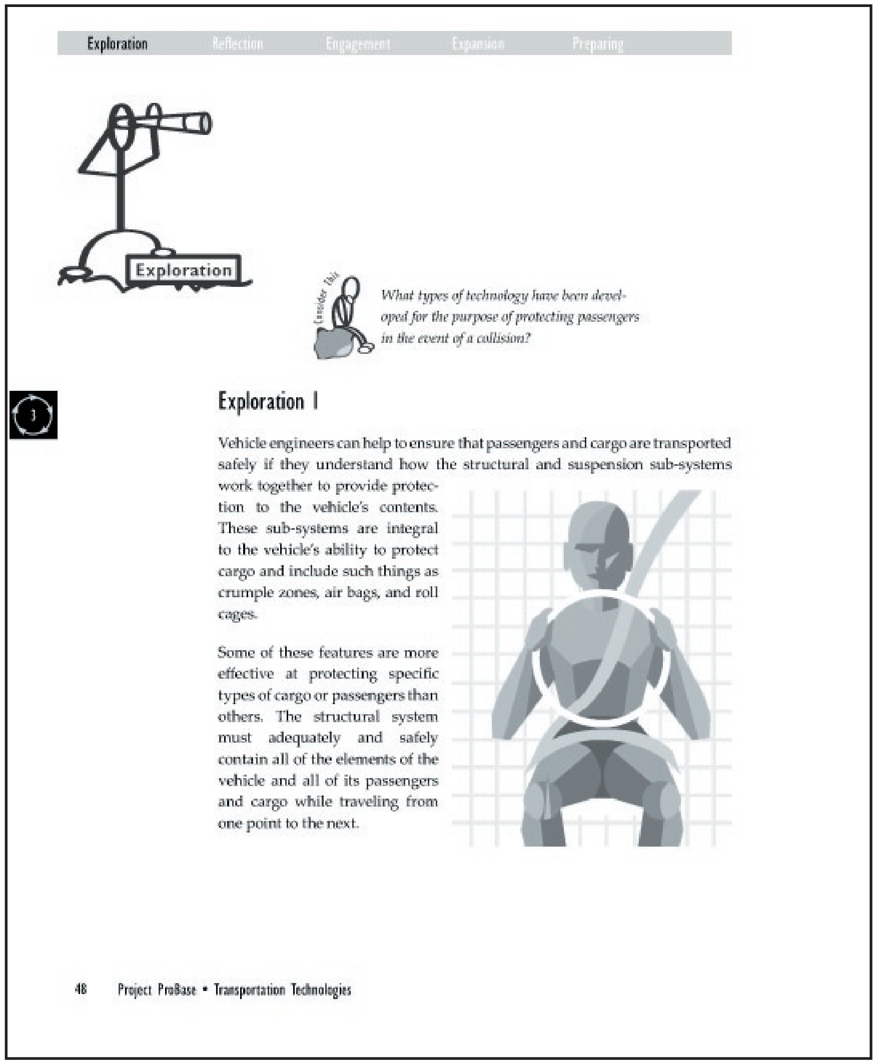
Masking tape

String

Egg (optional)

Teaching Tips

Potential discussion questions have been included in the Student Guide to aid the students' research. Suggested topics for student research are listed below. You may add to this list; however, the topics should be narrow so that students can successfully locate information about the topic in a short time period.



Exploration Reflection Engagement Expansion Preparing

What types of technology have been developed for the purpose of protecting passengers in the event of a collision?

Exploration I

Vehicle engineers can help to ensure that passengers and cargo are transported safely if they understand how the structural and suspension sub-systems work together to provide protection to the vehicle's contents. These sub-systems are integral to the vehicle's ability to protect cargo and include such things as crumple zones, air bags, and roll cages.

Some of these features are more effective at protecting specific types of cargo or passengers than others. The structural system must adequately and safely contain all of the elements of the vehicle and all of its passengers and cargo while traveling from one point to the next.

48 Project ProBase • Transportation Technologies

Exploration I

This activity requires students to conduct research about a topic that you assign to them, related to transportation safety. They are required to gather as much information as possible about the assigned topic before the next class period and be prepared to discuss their findings.

Suggested Research Topics:

Struts, Shock Absorbers, Crash Test, Crash Test Dummies, Crumple Zones, F=MA, Safety Harnesses, Seat Belts, Suspension Systems, Safety Feature, Structural Integrity, Air Shocks, Hydraulic Shocks, Pneumatic Shocks, Air Bags, Roll Cages, Packing/Cushioning Materials

Exploration | Reflection | Engagement | Expansion | Preparing

Your instructor will randomly assign you a research topic related to vehicle safety in an effort to cover the necessary information (without replication) in the shortest time possible. You are required to gather as much information as possible about your assigned topic before the next class meeting, and be prepared to discuss your findings with the class. Some of the questions that will initiate your class discussion are listed below to help guide your research and prepare your discussion points. You should also complete the Inventor's Logbook entries in the spaces provided.

Potential Discussion Questions

1. How can members of the public, politicians, or the state of the economy influence the design of new products and systems in the transportation industry?
2. What safety features are included in transportation structural sub-systems?
3. How and why have structural safety features changed since the first vehicles were created? What events caused these changes?
4. How can we minimize the impact force on a passenger or cargo within a vehicle?

Provide your research topic here:

____

List at least three interesting findings related to your assigned topic here:

____

____

____

Inventor's Logbook

Logbook 3.1

Notes:

Teaching Tips

One of the goals of this discussion is to connect the topics that students have already identified to the concepts that they will explore in this learning cycle. For example, Newton's second law of motion which states that the applied force (F) equals the mass (M) of an object times the accelration (A) or (F=MxA)) and crumple zone design. One way to initiate a lively discussion is to begin the class period with a demonstration that connects several of these concepts.

3

Here are some guidelines for this demonstration:

- Suspend fabric, such as a bed sheet, so that it is free to move at the bottom and is high enough to allow for an egg to be thrown into the cloth.
- Cover the floor surrounding the fabric with plastic to aid in clean up.
- Have one of your strongest students throw an egg into the material as the class observes the impact. It is best to have some students standing on the sides of the fabric so that they can observe how the material deflects the impact of the egg. They should watch the fabric's profile on impact.
- Have another student drop an egg onto the plastic from shoulder height as the other students observe the egg's impact.

Obviously, the egg dropped on to a hard surface will break. Less obvious is an egg's ability to withstand the impact when thrown against a flexible material like a bed sheet. What needs to be highlighted through the resulting discussion is that if we increase the time over which an object decelerates, we minimize the force on the object. Students will be completing a mathematical analysis sheet that further explores this concept after they have completed the *Engagement* activity. The *Engagement* directly relates to the topics students have identified through research; such as crumple zones designed into vehicles, the goal of effective suspension systems, and other safety features.

Teaching Tips

The following questions are presented in the Student Guide to stimulate thinking and guide their search for information related to transportation safety. You should lead a discussion regarding this information as soon as you have completed the egg-deceleration demonstration.

1. How can members of the public, politicians, or the state of the economy influence the design of new products and systems in the transportation industry?
   - *Lobby groups can petition for higher safety standards.*
   - *If the state of the economy is good, innovations such as magnetic levitation trains are more likely to be installed.*
   - *Politicians can pass laws about such things as child restraints or airbags to improve safety features.*

2. What safety features are included in structural subsystems?
   Examples include roll bars, bumpers, and door rails to absorb side impacts.

3. How and why have structural safety features changed since the first vehicles were created? What events caused these changes?
   One reason that structural safety features have changed over the years is that we drive faster today and require more safety features to protect us on impact. The Ford Pinto (mid 1970s) that exploded on rear impact is one example of an event that caused changes to the structural safety built into vehicles.

4. How can we minimize the impact force on a vehicle?
   Side door rails, airbags, crumple zones, and better bumpers are all examples of things that have been created to minimize the impact force on a vehicle. To minimize the impact force on a vehicle, the distance over which a vehicle decelerates must be increased.

Exploration II

Teaching Tips

This activity will require students to construct and test three types of suspension systems for protecting cargo: magnetic, mechanical, and fluid. Diagrams like the ones on the following page (without labels) are included in the student text. Students will construct the suspension devices using the materials you provide them.

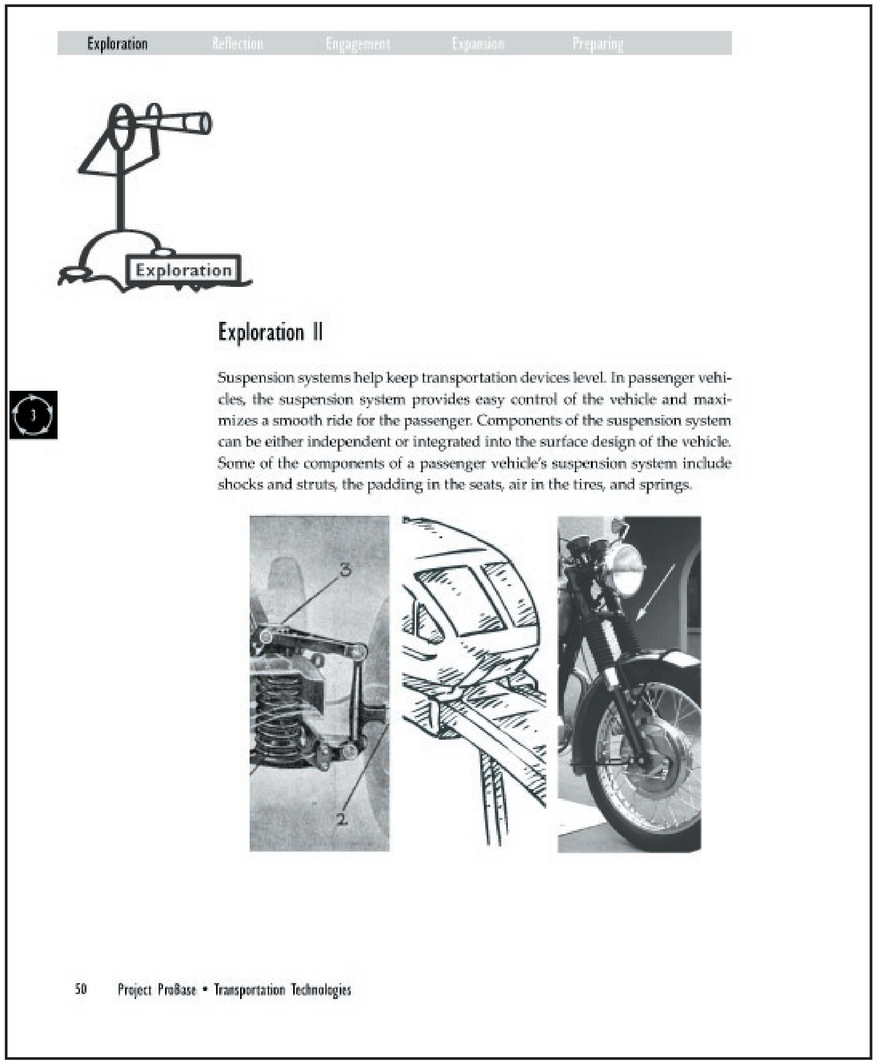
Teaching Tips

Before purchasing large quantities of materials, make sure that the rubber stoppers will fit the fluorescent light shield and drain pipe. If the stopper does not fit the light shield snugly, students can apply hot glue around the stopper to produce a better fit.

To streamline this activity, you should prepare the bases for the suspension systems by nailing the rubber stoppers to the center of each board before students begin this activity. Also, to save resources, you may have each team reuse their boards and fluorescent light shields for each of the three systems. This, however, will lengthen the time spent completing the activity.

Students will need to experiment with the length of the fluorescent light shield to determine the appropriate size for each system. (Each system should work best if the light shield is approximately 7" to 8" long.)

After each device is constructed, it should be tested by pulling it in a wagon over a given course. The drain pipe should be filled to the brim with water. The amount of water should be measured before and after running the course to assess the effectiveness of each suspension system (in this case, the more water spilled, the less effective the system). To streamline this activity, you should prepare the bodies for the suspension systems by mounting the plastic tubes onto boards that will fit inside the wagons before students begin this activity.


Exploration Reflection Engagement Expansion Preparing

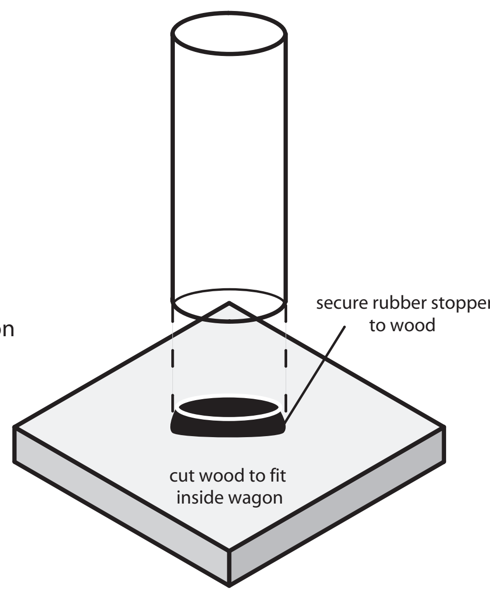
Exploration

Exploration II

Suspension systems help keep transportation devices level. In passenger vehicles, the suspension system provides easy control of the vehicle and maximizes a smooth ride for the passenger. Components of the suspension system can be either independent or integrated into the surface design of the vehicle. Some of the components of a passenger vehicle's suspension system include shocks and struts, the padding in the seats, air in the tires, and springs.

50 Project ProBase • Transportation Technologies

Example for preparing suspension system body



Your instructor will assign you to a three-person team for this *Exploration* activity as you explore suspension systems. Each team will construct and test three different suspension systems (i.e., mechanical, fluid, and magnetic). Your instructor will provide the basic structure (a tube mounted to a board) that you will use to construct each suspension system. You will be required to remain within the following parameters:

Design Criteria/Constraints

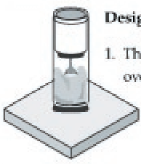


Figure 1. Fluid suspension

1. The container will be filled with water and transported over rough terrain in a wagon.
2. Each team should construct each of the suspension systems, similar to the ones illustrated in Figures 1-3 at the left, using the materials provided. Experiment with different lengths of light shield to determine the best length for each system. Make small adjustments as you experiment.

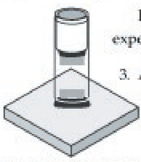


Figure 2. Magnetic suspension

3. After constructing each suspension system, transport the wagon over the designated course using the given suspension system.
4. Measure and record the amount of water lost during transit to determine the most effective suspension system.

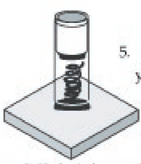


Figure 3. Mechanical suspension

5. Complete all three suspension systems and record your observations.
6. You will have two days to complete this assignment.

Teaching Tips

Prepare the course over a rough terrain such as gravel. The course should be several meters long and the pathway should be clearly marked using masking tape or string.

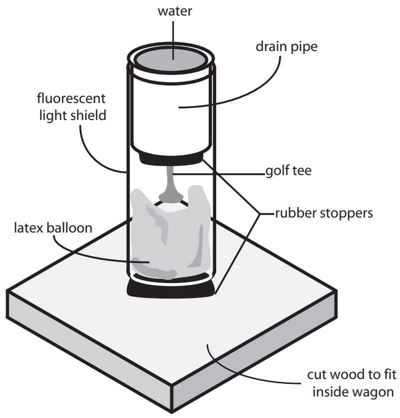


Figure 1-a. Fluid suspension
Note: Drawing is not to scale

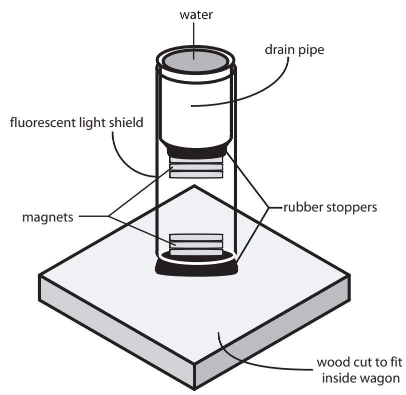


Figure 2-a. Magnetic suspension
Note: Drawing is not to scale

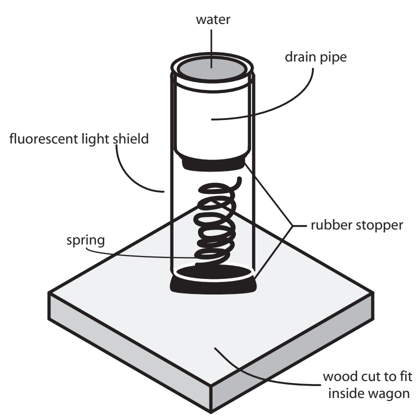


Figure 3-a. Mechanical suspension
Note: Drawing is not to scale

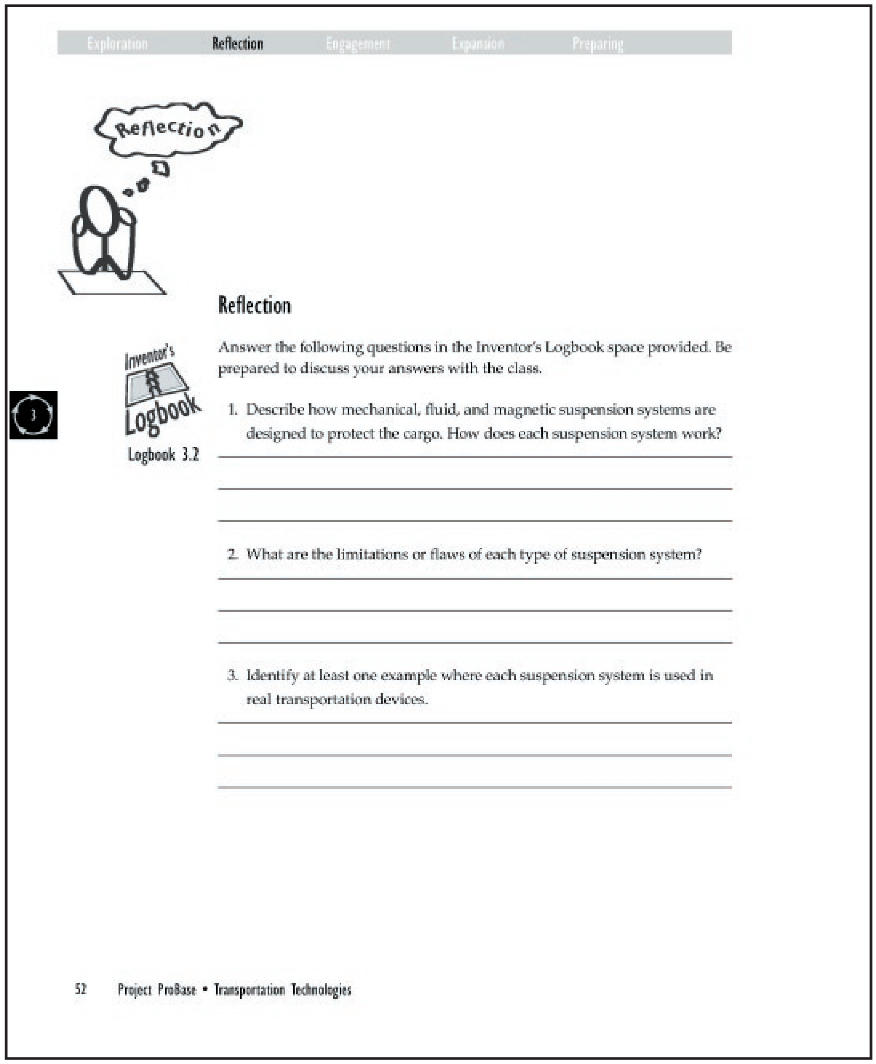
Reflection

Students are asked to answer the following questions in the Inventor's Logbook space provided.

1. Describe how mechanical, fluid, and magnetic suspension systems are designed to protect the cargo. How does each suspension system work?

2. What are the limitations or flaws of each type of suspension system?

3. Identify at least one example where each suspension system is used in real transportation devices.



Exploration Reflection Engagement Expansion Preparing

Reflection

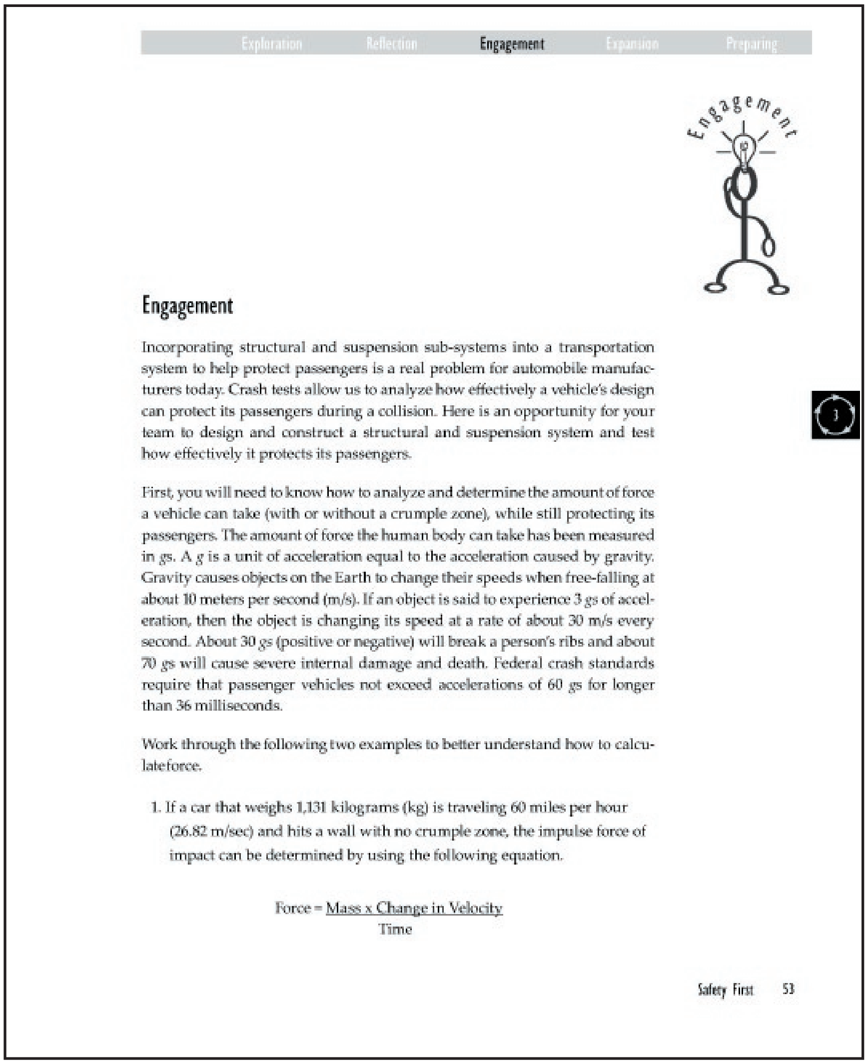
Answer the following questions in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

1. Describe how mechanical, fluid, and magnetic suspension systems are designed to protect the cargo. How does each suspension system work?

2. What are the limitations or flaws of each type of suspension system?

3. Identify at least one example where each suspension system is used in real transportation devices.

52 Project ProBase • Transportation Technologies


Exploration Reflection Engagement Expansion Preparing

Engagement

Incorporating structural and suspension sub-systems into a transportation system to help protect passengers is a real problem for automobile manufacturers today. Crash tests allow us to analyze how effectively a vehicle's design can protect its passengers during a collision. Here is an opportunity for your team to design and construct a structural and suspension system and test how effectively it protects its passengers.

First, you will need to know how to analyze and determine the amount of force a vehicle can take (with or without a crumple zone), while still protecting its passengers. The amount of force the human body can take has been measured in *gs*. A *g* is a unit of acceleration equal to the acceleration caused by gravity. Gravity causes objects on the Earth to change their speeds when free-falling at about 10 meters per second (m/s). If an object is said to experience 3 *gs* of acceleration, then the object is changing its speed at a rate of about 30 m/s every second. About 30 *gs* (positive or negative) will break a person's ribs and about 70 *gs* will cause severe internal damage and death. Federal crash standards require that passenger vehicles not exceed accelerations of 60 *gs* for longer than 36 milliseconds.

Work through the following two examples to better understand how to calculate force.

1. If a car that weighs 1,131 kilograms (kg) is traveling 60 miles per hour (26.82 m/sec) and hits a wall with no crumple zone, the impulse force of impact can be determined by using the following equation.

$$\text{Force} = \frac{\text{Mass x Change in Velocity}}{\text{Time}}$$

Safety First 53

You may need to assist the students in completing the mathematical analysis sheet. Each team will need to record the mass of their vehicle with cargo, the distance the car traveled, and the time in which the car traveled. If you have TI graphing calculators available, you may want to use the photo-gate technology to assist students in completing their analysis. The TI graphing calculator can provide the impulse force at impact.

If this device is not available, students should use .01 seconds for the time of deceleration without a crumple zone and .10 for time of deceleration with a crumple zone. By giving students these two times, they can focus on the science involved in crumple zone technology and its relationship to impulse force at impact.

Engagement

This design activity provides an opportunity for students to apply what they have learned about structural and suspension systems and explain how those systems work together to protect a vehicle's cargo. Each team must complete the mathematical analysis sheet, which is provided in the Appendix of this guide.

Notes:

The mass of the car is 1,131 kg and the change in velocity was 26.2 meters per second. Time in the above equation is the measurement of the amount of time it takes for the vehicle to decelerate or hit the wall and stop. For this example, the deceleration time was .01 second (s). So, the amount of force is 3,033,342 newtons (N).

$$\text{Force} = \frac{1131 \text{ kg} \times 26.82 \text{ m/sec}}{.01 \text{ s}} = 3{,}033{,}342 \text{ N}$$

2. Now, what if the same car is traveling at the same rate and hits the same target, but with a 1.5 meter crumple zone? In this example, the deceleration time increased to .1119 second. Using the same equation F= (Mass x Change in Velocity)/Time, you can see that the impulse force of impact was drastically reduced:

$$\text{Force} = \frac{1131 \text{ kg} \times 26.82 \text{ m/sec}}{.1119} = 271{,}076 \text{ N}$$

Using the previous examples, would a passenger survive either of the impacts?

In the first example, the possible *g* force applied to a passenger can be found by using the equation below:

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Change in Time}}$$

The change in velocity is found by subtracting the speed upon impact, which was 26.82 m/s from the starting speed of 0 m/s. That number is then divided by the amount of time it took for the vehicle to travel from the starting point to the point of impact to find the acceleration in *g*s. In the first example, the acceleration was -273 *g*s. This is well above the amount of *g*s that are considered safe! Remember, just 70 *g*s (positive or negative) can kill a passenger.

$$\text{Acceleration} = \frac{(0\text{ m/s}-26.82\text{ m/s})}{.01\text{ s}} = \frac{-26.82\text{ m/s}}{.01\text{ s}} = -2{,}682\text{ m/s}^2 \times \frac{1\,g}{9.8\text{ m/s}^2} = -273.7\,g$$

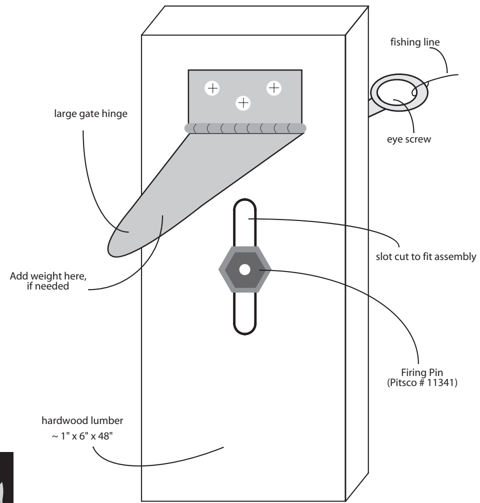
For the second example with the 1.5 m crumple zone, the acceleration was -24.46 *g*s. In this example, the crumple zone could have meant the difference between life and death for a passenger.

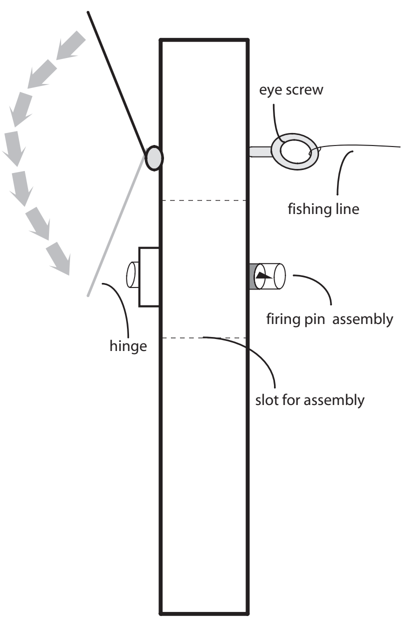
$$\text{Acceleration} = \frac{(0\text{m/s}-26.82\text{ m/s})}{.1119\text{ sec}} = \frac{-26.82\text{ m/s}}{.1119\text{ sec}} = -239.7\text{ m/s}^2 \times \frac{1\,g}{9.8\text{ m/s2}} = -24.46\,g$$

3

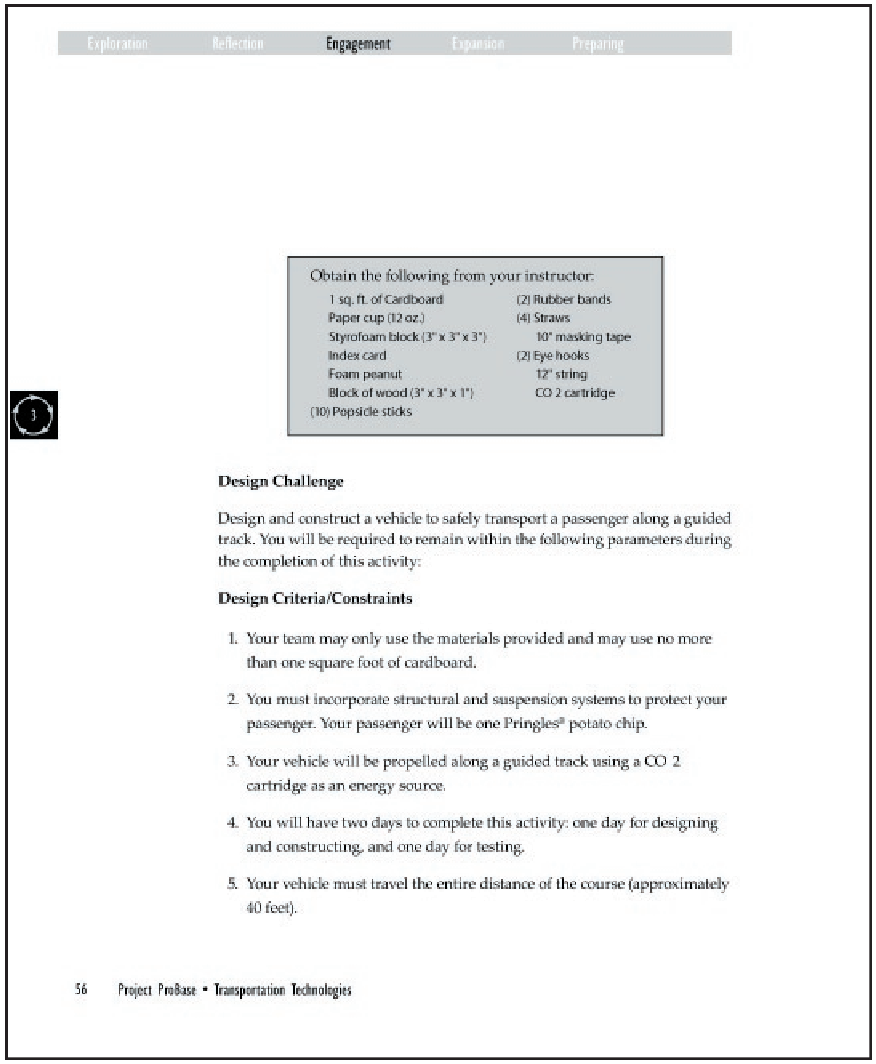
Notes:

Suggested setup for firing pin assembly used in *Engagement* activity.
Note: drawings not to scale





Firing pin assembly side view



Exploration Reflection Engagement Expansion Preparing

Obtain the following from your instructor:

1 sq. ft. of Cardboard	(2) Rubber bands
Paper cup (12 oz.)	(4) Straws
Styrofoam block (3" x 3" x 3")	10" masking tape
Index card	(2) Eye hooks
Foam peanut	12" string
Block of wood (3" x 3" x 1")	CO 2 cartridge
(10) Popsicle sticks	

Design Challenge

Design and construct a vehicle to safely transport a passenger along a guided track. You will be required to remain within the following parameters during the completion of this activity:

Design Criteria/Constraints

1. Your team may only use the materials provided and may use no more than one square foot of cardboard.
2. You must incorporate structural and suspension systems to protect your passenger. Your passenger will be one Pringles® potato chip.
3. Your vehicle will be propelled along a guided track using a CO 2 cartridge as an energy source.
4. You will have two days to complete this activity: one day for designing and constructing, and one day for testing.
5. Your vehicle must travel the entire distance of the course (approximately 40 feet).

56 Project ProBase • Transportation Technologies

Teaching Tips

The pin assembly will need to be ordered to allow enough time for shipping.

You will need to construct the launcher prior to beginning this activity. Plans for one type of launching system are shown here and the materials are listed in the *Equipment and Materials* section.

Exploration | Reflection | **Engagement** | Expansion | Preparing

6. The vehicle must attach to the track (fishing line) using eye hooks and must accommodate a standard CO_2 cartridge. Be aware of the distance from the track to the CO_2 cartridge. Your vehicle's CO_2 cartridge must line up with the pin on the launching device.
7. Your team must provide an illustration for your design. This can be a pencil sketch or CAD drawing.
8. Your vehicle must weigh between 40 and 70 grams.
9. You must complete the mathematical analysis sheet provided by your instructor.
10. A rubric will be used to assess the effectiveness of your design. A cracked chip is considered a failure.
11. You will work in your *Primary Challenge* teams for this activity. Be sure to take advantage of the design work completed by each team.

Safety

Vehicles will be suspended on a fishing line and travel at high speeds. All components should be secure and checked by your instructor before launching each vehicle. All spectators should stand a safe distance from the test track. No one should be allowed to stand near the end of the track because vehicle parts may fly on impact.

3

Safety First 57

Teaching Tips

The track line must be pulled as tightly as possible in order to minimize the effects of gravity as the vehicle travels. It also needs to be removable so that you can attach and remove vehicles quickly and easily.

Students should assume specific jobs to make the launch cycle time go faster. You may consider having someone in charge of putting the vehicles on, others taking them off, some students cleaning up, others launching the vehicles, and additional students completing other tasks as they arise.

Teaching Tips

If you do not want to construct the firing pin assembly, students can drop their vehicles (with some additional weight) from a large height, such as the top of a set of bleachers.

Teaching Tips

If the hinge does not produce enough force, students may lightly hit the firing pin or spring-loaded center punch with a mallet.

Teaching Tips

The launcher needs to be secured. A metal or woodworking vice works well. The track (fish line) for travel of the vehicle should extend approximately 40 feet and attach to the wall (or concrete block) where the vehicles will crash.

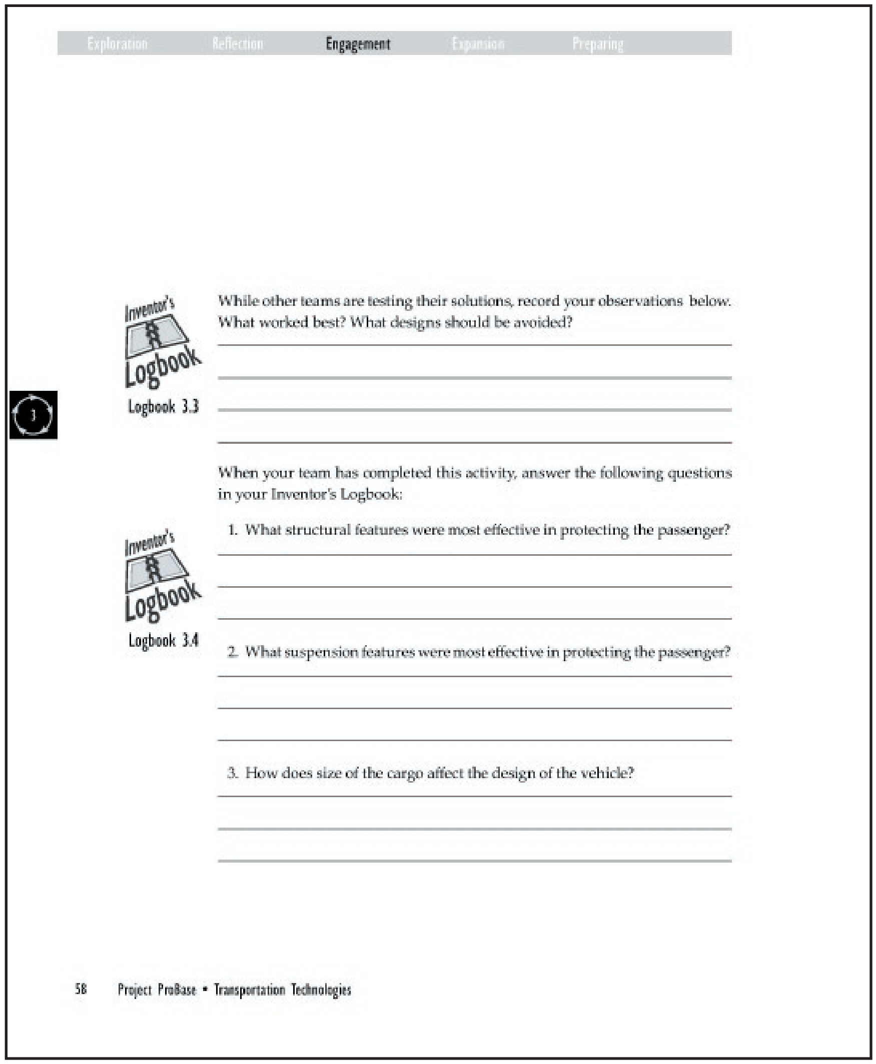
The housing for the CO 2 cartridge must be at least 1" deep with a ¾" diameter hole. The students may use masking tape around the cartridge, if necessary, to ensure a snug fit within the housing.

3

While other teams are testing their solutions, you can direct students to record their observations in the space provided.

The analysis of the system is an important aspect of this project. Students should analyze their solutions and at least one other solution as they address the following questions posed in the student text. Students should write their responses to the following questions in the Inventor's Logbook spaces provided.

1. What structural features were most effective in protecting the passenger?
2. What suspension features were most effective in protecting the passenger?
3. How does size of the cargo affect the design of the vehicle?


Exploration Reflection Engagement Expansion Preparing

Inventor's Logbook

Logbook 3.3

While other teams are testing their solutions, record your observations below. What worked best? What designs should be avoided?

When your team has completed this activity, answer the following questions in your Inventor's Logbook:

Inventor's Logbook

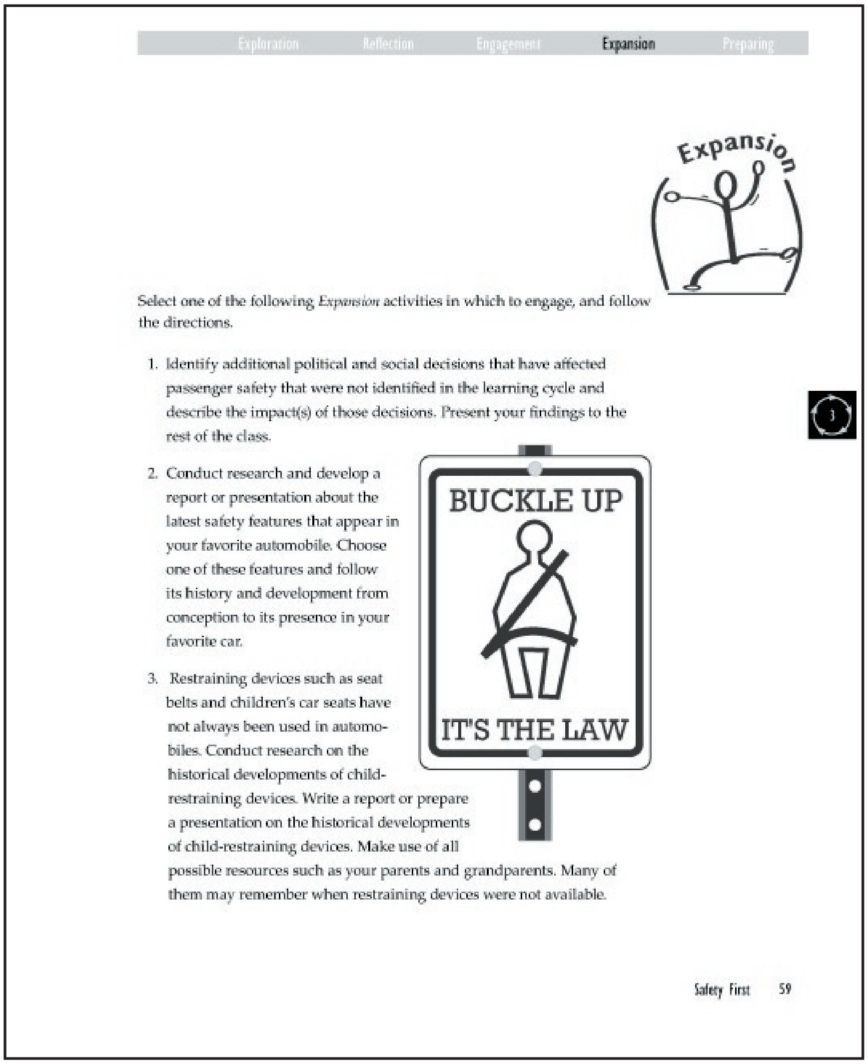
Logbook 3.4

1. What structural features were most effective in protecting the passenger?
2. What suspension features were most effective in protecting the passenger?
3. How does size of the cargo affect the design of the vehicle?

58 Project ProBase • Transportation Technologies

Safety

Vehicles will be suspended on a fishing line and travel at high rates of speed. All components should be secure and checked by you before launching each vehicle. All spectators should stand a safe distance from the test track. No one should be allowed to stand near the end of the track because vehicle parts may fly on impact.



Exploration Reflection Engagement Expansion Preparing

Expansion

Select one of the following *Expansion* activities in which to engage, and follow the directions.

1. Identify additional political and social decisions that have affected passenger safety that were not identified in the learning cycle and describe the impact(s) of those decisions. Present your findings to the rest of the class.
2. Conduct research and develop a report or presentation about the latest safety features that appear in your favorite automobile. Choose one of these features and follow its history and development from conception to its presence in your favorite car.
3. Restraining devices such as seat belts and children's car seats have not always been used in automobiles. Conduct research on the historical developments of child-restraining devices. Write a report or prepare a presentation on the historical developments of child-restraining devices. Make use of all possible resources such as your parents and grandparents. Many of them may remember when restraining devices were not available.

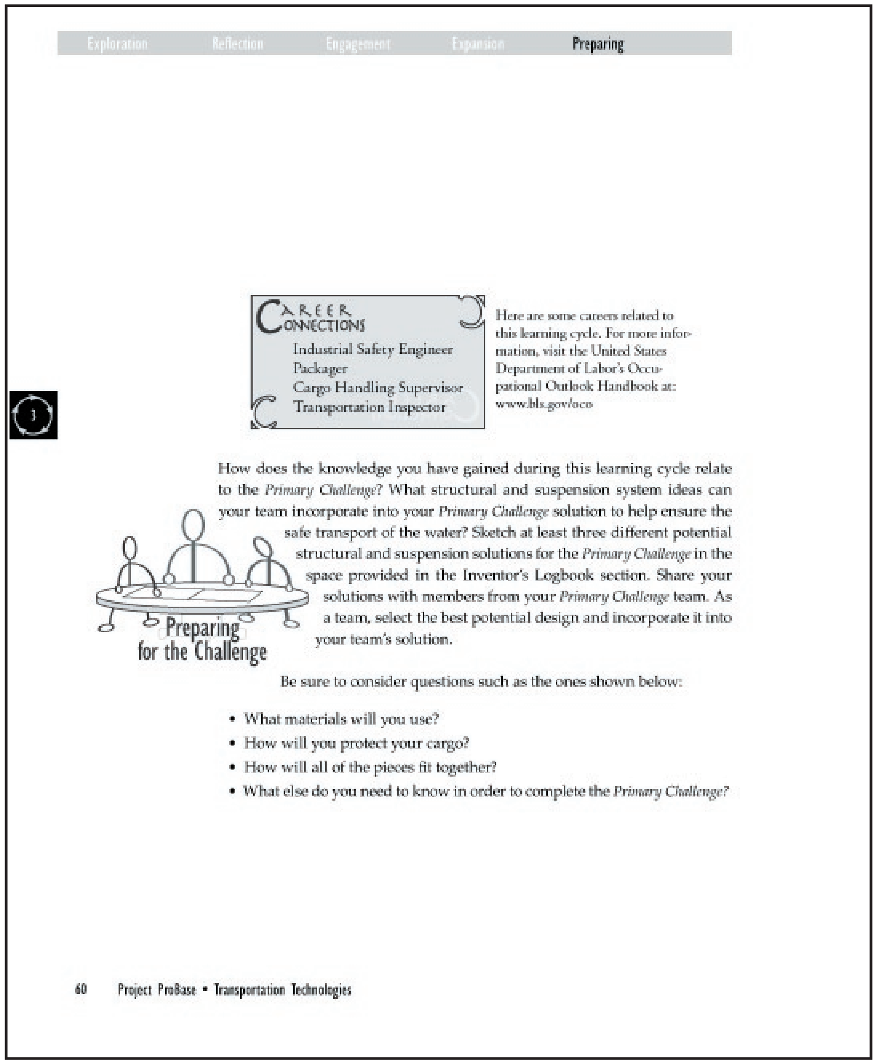
Safety First 59

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

Students should select only one of these options.

1. Identify additional political and social decisions that have affected passenger safety that were not identified in *Reflection I* and describe the impact(s) of those decisions.
2. Conduct research and develop a report or presentation about the latest safety features that appear in your favorite automobile. Choose one of these features and follow its history and development from conception to its presence in your favorite car.
3. Restraining devices such as seat belts and children's car seats have not always been used in automobiles. Conduct research and write a report or give a presentation about the historical developments of child-restraining devices. As you conduct your research, consider asking your parents or grandparents their recollections of these safety features; they may remember when restraining devices were not available.



Exploration | Reflection | Engagement | Expansion | **Preparing**

CAREER CONNECTIONS
Industrial Safety Engineer
Packager
Cargo Handling Supervisor
Transportation Inspector

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

3

Preparing for the Challenge

How does the knowledge you have gained during this learning cycle relate to the *Primary Challenge*? What structural and suspension system ideas can your team incorporate into your *Primary Challenge* solution to help ensure the safe transport of the water? Sketch at least three different potential structural and suspension solutions for the *Primary Challenge* in the space provided in the Inventor's Logbook section. Share your solutions with members from your *Primary Challenge* team. As a team, select the best potential design and incorporate it into your team's solution.

Be sure to consider questions such as the ones shown below:

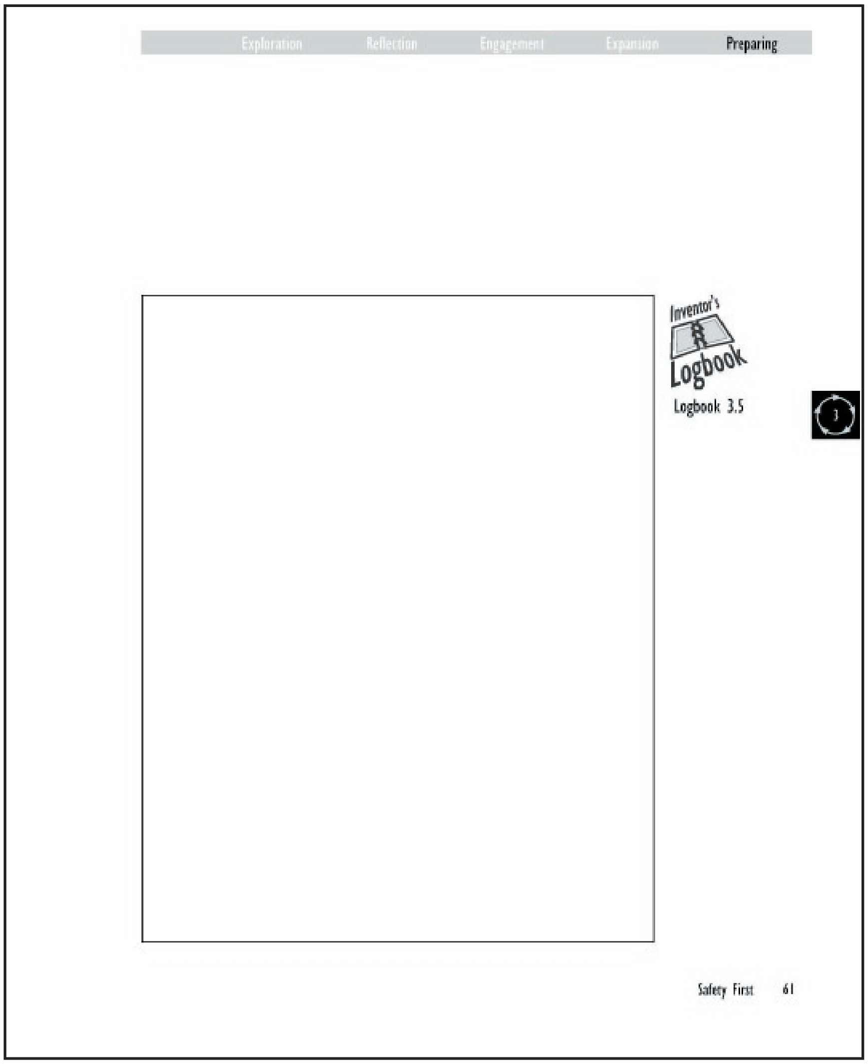
- What materials will you use?
- How will you protect your cargo?
- How will all of the pieces fit together?
- What else do you need to know in order to complete the *Primary Challenge?*

60 Project ProBase • Transportation Technologies

3

Preparing for the Challenge

Students should develop structural and suspension system ideas from these activities that can be incorporated into their solution of the *Primary Challenge.* You should give them some class time to brainstorm within their *Primary Challenge* teams, sketch some plausible solutions, and decide as a team which design they will incorporate into their solution to the *Primary Challenge.*


Exploration Reflection Engagement Expansion Preparing

Inventor's Logbook

Logbook 3.5

3

Safety First 61

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

3

Safety First!

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Presentation and Communication Preparation	Exceptional preparation of presentation with strong visual aids/handouts/ appropriate technology.	Above average preparation of presentation with good visual aids/handouts/ appropriate technology.	Average preparation of presentation; basic visual aids/handouts/ appropriate technology.	Below average preparation of presentation.	
Effectiveness	Presentation was exceptionally effective, clear, and accurate.	Presentation effectiveness, clarity, and accuracy were above average.	Presentation effectiveness, clarity, and accuracy were average.	Presentation effectiveness, clarity, and accuracy were below average.	
Informative and Interesting	Presentation was exceptionally informative and interesting.	Presentation was highly informative and interesting.	Presentation was informative and interesting.	Presentation was neither informative nor interesting.	
Suspension Testing Apparatus Construction	Construction is of exceptional quality.	Construction is above average quality.	Construction is average quality.	Construction is below average quality.	
Safety Vehicle Design and Documentation Design	Exceptional creativity and innovation in design.	Above average creativity and innovation in design.	Average creativity and innovation in design.	Below average creativity and innovation in design.	
Mathematical Analysis	Exceptional documentation of research and design.	Above average documentation of research and design.	Average documentation or research and design.	Below average documentation of research and design.	
Functionality and Construction	Vehicle works well and is constructed well.	Vehicle works well; construction is average.	Vehicle works average; construction is below average.	Vehicle doesn't work, construction is below average.	
Inventor's Logbook Suspension	Fully comprehends suspension.	Comprehends suspension.	Comprehends suspension somewhat.	Does not comprehend suspension.	
Structure	Fully comprehends structure.	Comprehends structure.	Comprehends structure somewhat.	Does not comprehend structure.	
				Total Points	

3

Learning Cycle Four

4

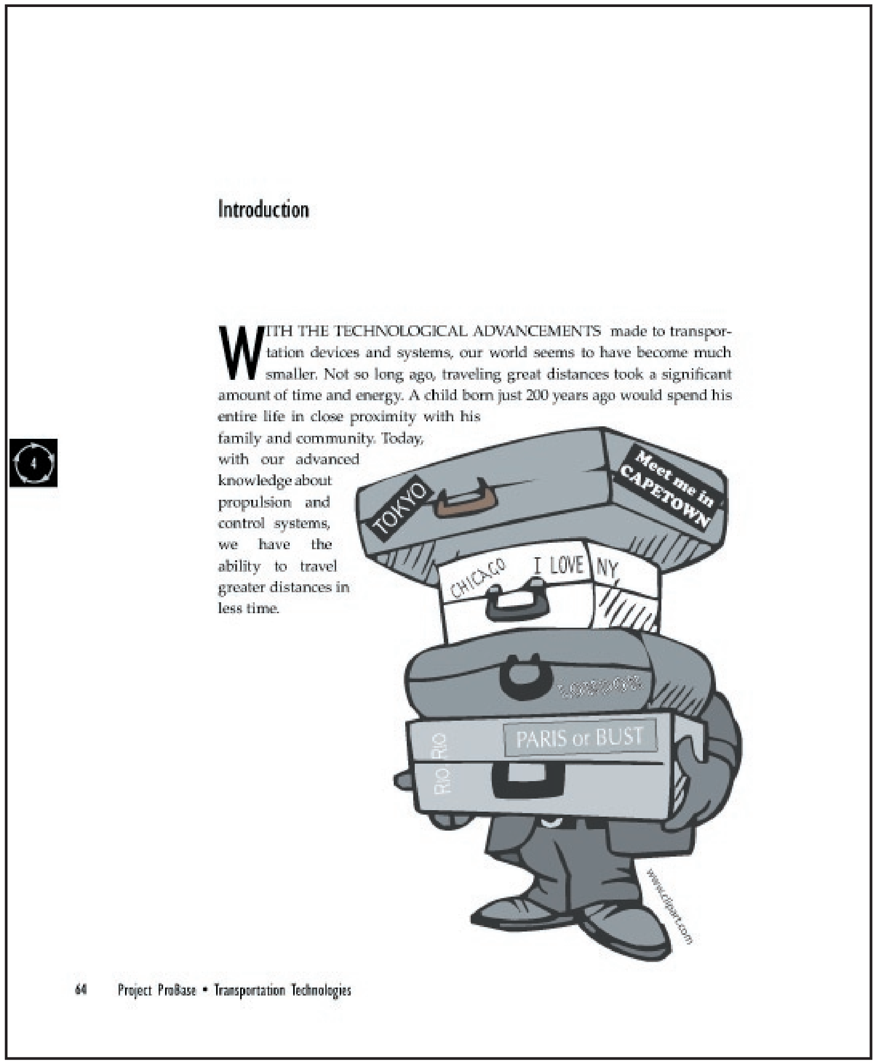
Out of Control!

4

Out of Control!

Introduction

The primary goal for this learning cycle is to have students explore the technical concept of control, and to begin to understand how these controls are applied to transportation systems. After completing this learning cycle, students will be able to identify different methods of controlling movement and apply this knowledge to their *Primary Challenge* solution.



Introduction

WITH THE TECHNOLOGICAL ADVANCEMENTS made to transportation devices and systems, our world seems to have become much smaller. Not so long ago, traveling great distances took a significant amount of time and energy. A child born just 200 years ago would spend his entire life in close proximity with his family and community. Today, with our advanced knowledge about propulsion and control systems, we have the ability to travel greater distances in less time.

64 Project ProBase • Transportation Technologies

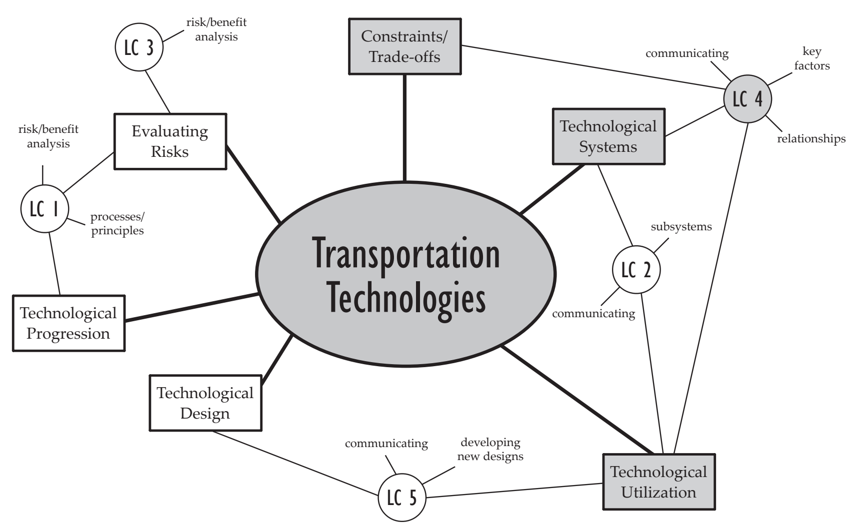
Objectives and Essential Questions

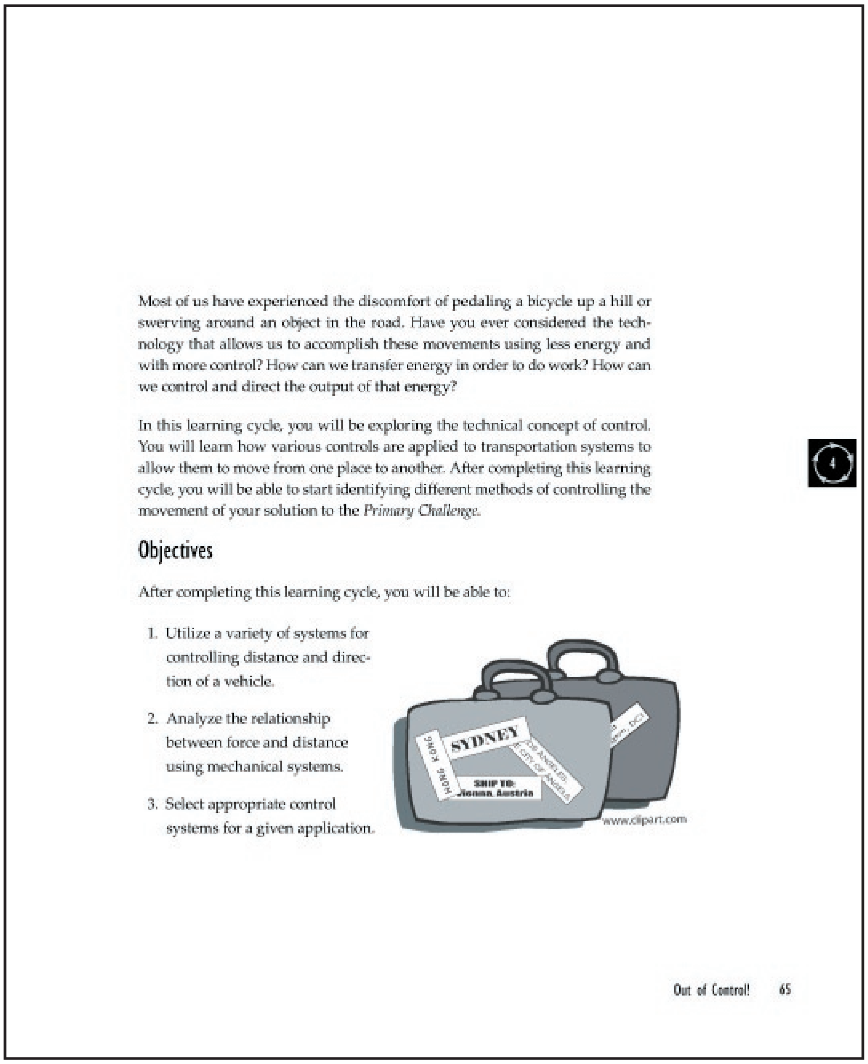
After completing this learning cycle, students will be able to:

1. Utilize a variety of systems for controlling distance and direction of a vehicle.

Essential Question 9b: How is technology used to control devices and systems and provide information to humans?

Transportation Technologies
Learning Cycle Four Concept Map





Most of us have experienced the discomfort of pedaling a bicycle up a hill or swerving around an object in the road. Have you ever considered the technology that allows us to accomplish these movements using less energy and with more control? How can we transfer energy in order to do work? How can we control and direct the output of that energy?

In this learning cycle, you will be exploring the technical concept of control. You will learn how various controls are applied to transportation systems to allow them to move from one place to another. After completing this learning cycle, you will be able to start identifying different methods of controlling the movement of your solution to the *Primary Challenge*.

Objectives

After completing this learning cycle, you will be able to:

1. Utilize a variety of systems for controlling distance and direction of a vehicle.
2. Analyze the relationship between force and distance using mechanical systems.
3. Select appropriate control systems for a given application.

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Out of Control! 65

2. Analyze the relationship between force and distance, using mechanical systems.

Essential Question 4b: What are the key elements of the various technological systems and what are the relationships between these systems?

3. Select appropriate control systems for a given application.

Essential Question 6b: What are the key factors that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems?

Facility Requirements

Exploration I will require access to the Internet and other resources. *Exploration II* works best in a classroom with tables large enough to allow students to work in pairs. The *Engagement* activity works best in a general laboratory equipped with basic tools and equipment; such as hand tools, drill press, table saw, band saw, etc.

Equipment and Materials

Based on a class of 28 students:

(14) Tongue depressors

(7) Paper hole punches

(84) Brass paper fasteners

(14) 6" x 8" pegboards with ⅛" or ¼" holes

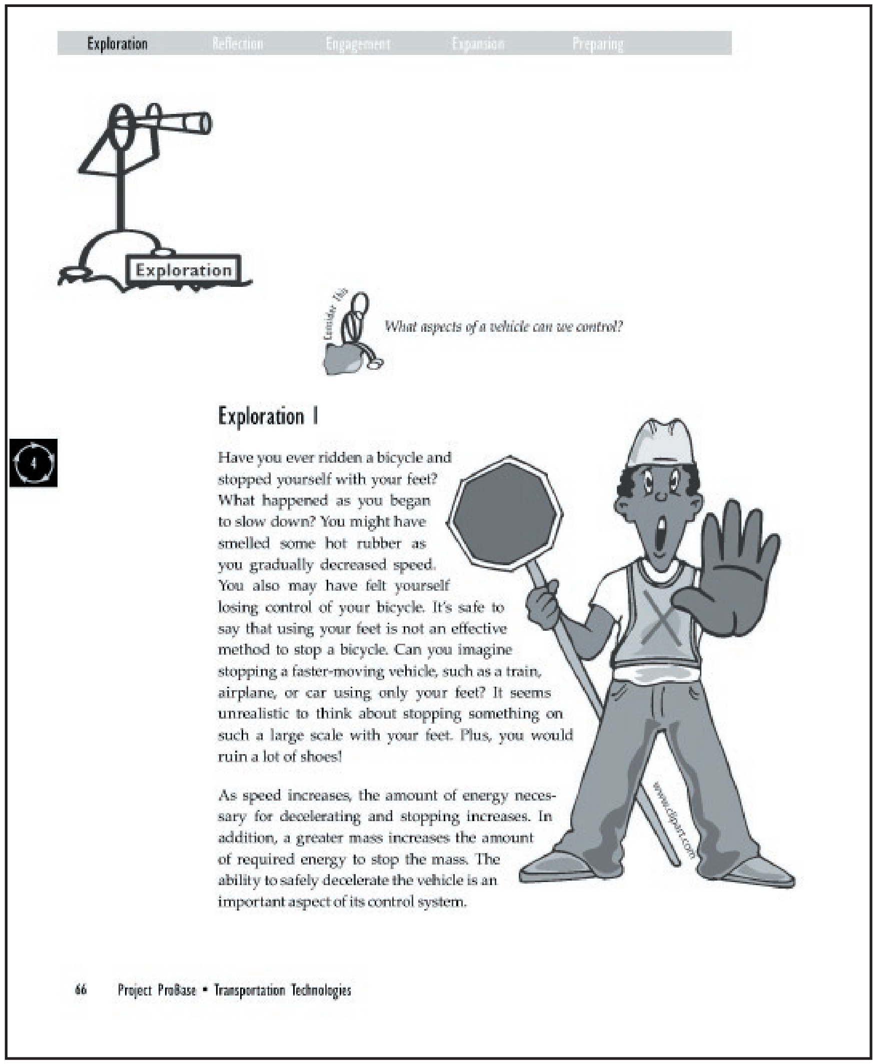
Various materials specified by solutions to the *Engagement* activity.

4

Estimated Number of 50-minute class periods: **7**

Suggested Daily Outline

Day One	Day Two
Introduction, *Exploration I*	*Exploration I* *Reflection I*
Day Three	**Day Four**
Exploration II	*Exploration II* *Reflection II*
Day Five	**Day Six**
Engagement	*Engagement*
Day Seven	
Engagement *Preparing for the Challenge*	


Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

What aspects of a vehicle can we control?

Exploration I

Have you ever ridden a bicycle and stopped yourself with your feet? What happened as you began to slow down? You might have smelled some hot rubber as you gradually decreased speed. You also may have felt yourself losing control of your bicycle. It's safe to say that using your feet is not an effective method to stop a bicycle. Can you imagine stopping a faster-moving vehicle, such as a train, airplane, or car using only your feet? It seems unrealistic to think about stopping something on such a large scale with your feet. Plus, you would ruin a lot of shoes!

As speed increases, the amount of energy necessary for decelerating and stopping increases. In addition, a greater mass increases the amount of required energy to stop the mass. The ability to safely decelerate the vehicle is an important aspect of its control system.

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Exploration I

Exploration I asks students to conduct research on the Internet or other available resources to discover the historical developments of one of the following types of braking systems: mechanical, hydraulic, pneumatic, or electrical. Students are also required to prepare a three- to five-minute presentation.

Exploration Reflection Engagement Expansion Preparing

Constraints/Requirements

Braking Systems
mechanical
hydraulic
pneumatic
electrical

Your instructor will assign you to a two-person team. Each team is responsible for conducting research to better understand how braking systems work.

Each team must also present their findings to the class in a three- to five-minute presentation.

The research and presentation should answer the following questions:

- How is friction produced in this braking system?
- On what transportation vehicles is this type of braking system common?
- Where might this braking system be used in the future?
- How can climatic factors such as ice, snow, or rain affect the control of a vehicle when this type of braking system is utilized?
- What are some of the safety trade-offs of using this type of braking system (e.g., health, cost, disposal)?

Out of Control! 67

Teaching tips

You should assign your students to two-person teams for this activity. Internet access is helpful, but not essential for this research. There is a rubric at the end of this learning cycle for grading student presentations. It is recommended that you copy and distribute this rubric to your students before they begin their presentations.

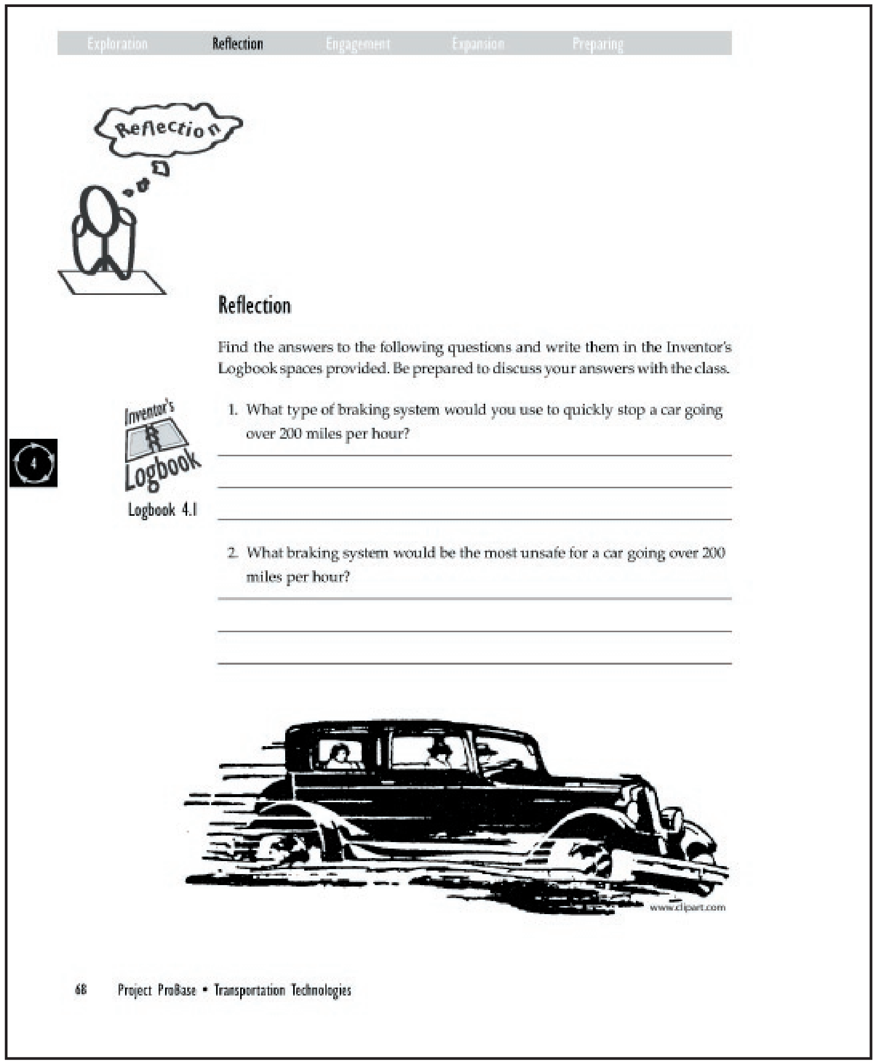
Teaching tips

Remind students that their presentations should be engaging and should present the following information related to the specific type of braking system they were assigned:

- How is friction produced?
- What are the most common applications of this type of braking system?
- What are some future applications?
- How can climatic factors, such as ice, snow, or rain, affect the control of a vehicle using this type of braking system?
- What are some of the safety trade-offs of using this type of braking system (e.g., health, cost, disposal)?

Reflection

If time is limited, students could do this *Reflection* as homework. Students are asked to find the answers to the following questions and write them in the Inventor's Logbook spaces provided.



Exploration Reflection Engagement Expansion Preparing

Reflection

Inventor's Logbook

Logbook 4.1

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Be prepared to discuss your answers with the class.

1. What type of braking system would you use to quickly stop a car going over 200 miles per hour?
2. What braking system would be the most unsafe for a car going over 200 miles per hour?

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68 Project ProBase • Transportation Technologies

1. What type of braking system would you use to stop a car going over 200 miles per hour?
   A hydraulic system with disc brakes made from carbon materials would work best.

2. What braking system would be the most unsafe for a car going over 200 miles per hour?
   A pneumatic brake system would probably be the most unsafe because of the heat build up during braking.

3. How has the need or desire for speed affected or changed the technologies used for braking systems?
   Materials are being developed for braking systems that will withstand very high temperatures caused by friction, and engineers have created independent front and rear braking systems for high speed vehicles so that they can control the front and rear brake systems independently to account for the weight shifts that occur during high speed braking.

4. Beyond safety, how have braking systems improved transportation?
   Braking systems have allowed us to move faster.

5. Explain how stopping a car is more than just stepping on the brake pedal?
   Diagram what happens when the brake pedal is depressed.

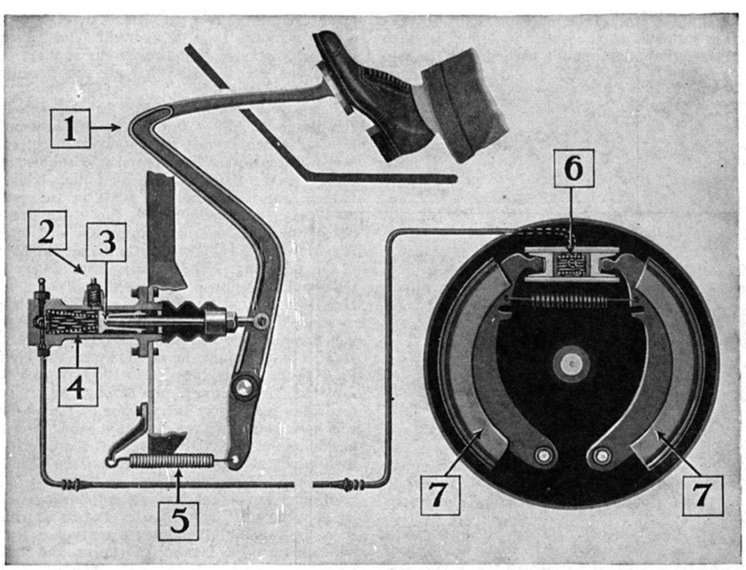
6. What causes a vehicle's brake pads to wear down?
   Friction causes the brake pads to wear down.

3. How has the need or desire for speed affected or changed the technologies used for braking systems?

4. Beyond safety, how have braking systems improved transportation?

5. Explain how stopping a car is more than just stepping on the brake pedal. Diagram what happens when the brake pedal is depressed.

6. What causes a vehicle's brake pads to wear down?



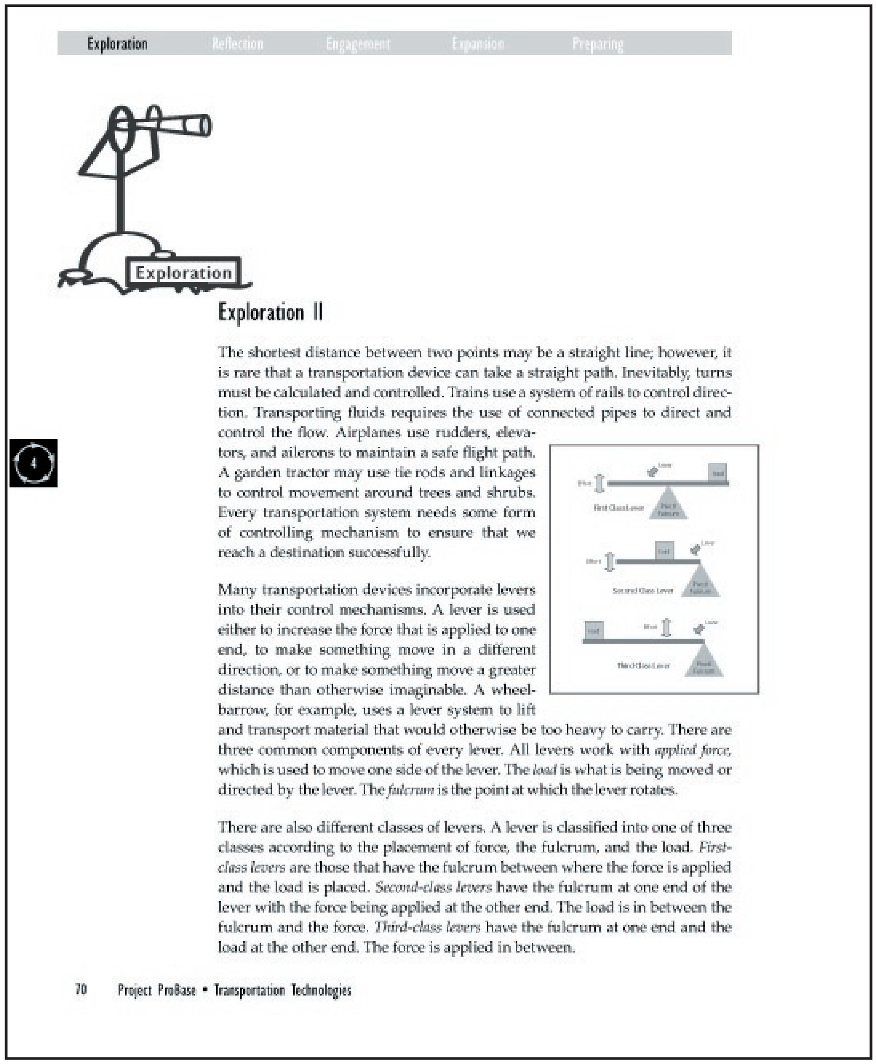
HYDRAULICS APPLIED TO THE AUTOMOBILE

The hydraulic brake for motor vehicles has supplanted mechanical brakes in many kinds of automobiles. The above illustration explains its action. (1) The foot brake pedal, where power is applied. (2) Master cylinder supply tube connection. (3) Piston. (4) Liquid. (5) Pedal return spring. (6) Wheel cylinder. (7) Brake shoes. The fluid is compressed, and the compression extends through pipes to the wheel cylinder, where expansion of the brake causes the necessary friction to stop the vehicle.

Example brake system

Exploration II

Exploration II asks the students to predict the outcome of various linkage configurations and then test their predictions using simple linkages. This is shown as Figure 1 in the Student Guide and explained further here in the Instructor Guide.



Exploration Reflection Engagement Expansion Preparing

Exploration

Exploration II

The shortest distance between two points may be a straight line; however, it is rare that a transportation device can take a straight path. Inevitably, turns must be calculated and controlled. Trains use a system of rails to control direction. Transporting fluids requires the use of connected pipes to direct and control the flow. Airplanes use rudders, elevators, and ailerons to maintain a safe flight path. A garden tractor may use tie rods and linkages to control movement around trees and shrubs. Every transportation system needs some form of controlling mechanism to ensure that we reach a destination successfully.

Many transportation devices incorporate levers into their control mechanisms. A lever is used either to increase the force that is applied to one end, to make something move in a different direction, or to make something move a greater distance than otherwise imaginable. A wheelbarrow, for example, uses a lever system to lift and transport material that would otherwise be too heavy to carry. There are three common components of every lever. All levers work with *applied force*, which is used to move one side of the lever. The *load* is what is being moved or directed by the lever. The *fulcrum* is the point at which the lever rotates.

There are also different classes of levers. A lever is classified into one of three classes according to the placement of force, the fulcrum, and the load. *First-class levers* are those that have the fulcrum between where the force is applied and the load is placed. *Second-class levers* have the fulcrum at one end of the lever with the force being applied at the other end. The load is in between the fulcrum and the force. *Third-class levers* have the fulcrum at one end and the load at the other end. The force is applied in between.

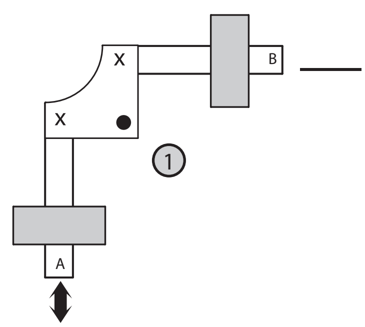
70 Project ProBase • Transportation Technologies

Teaching Tips

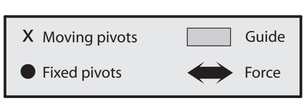
Assign your students to two-person teams. Lay out the necessary materials and allow each team to get the materials listed in their student text. Remind your students to write their predictions in the Inventor's Logbook spaces provided before constructing each of the linkage systems. Students should be able to punch the required holes in the tongue depressors using a paper punch. If preferred, a drill can be used to drill ¼" holes in the tongue depressors.

Safety

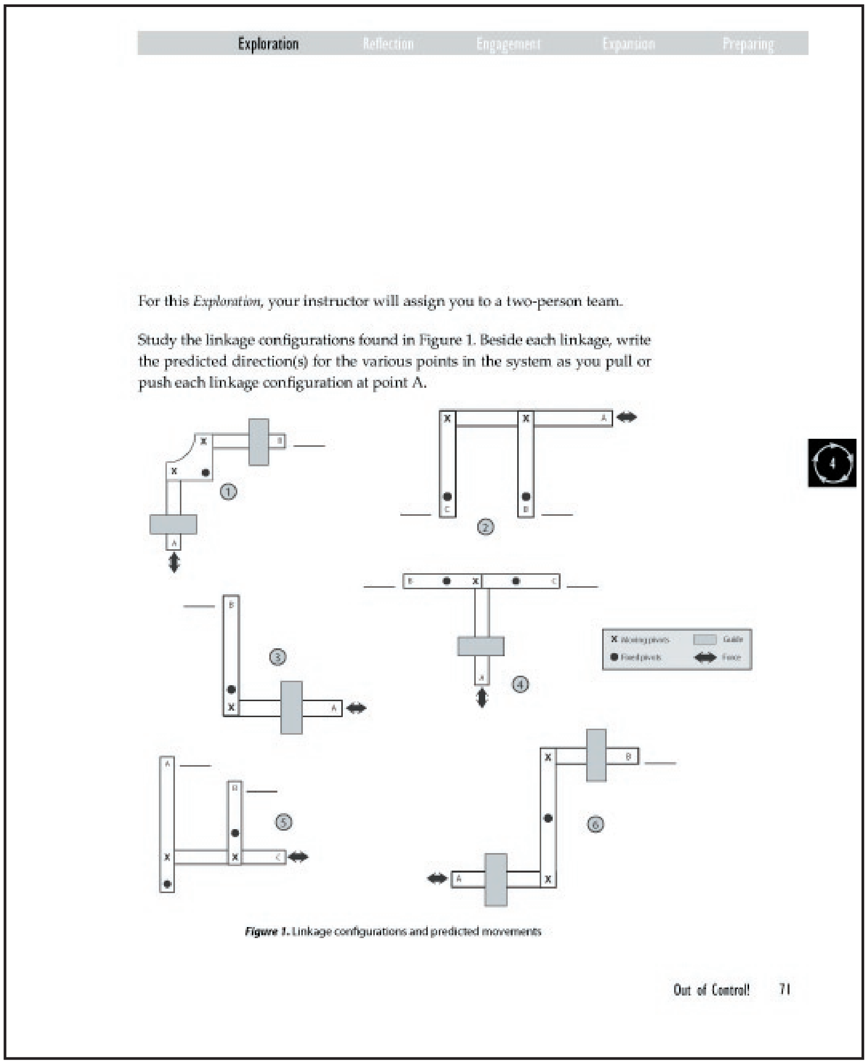
Remind students to punch or drill the holes near the center of the tongue depressors to prevent them from breaking or splintering.



When Point A is pulled down, B moves to the left. If A goes up, B moves to the right.



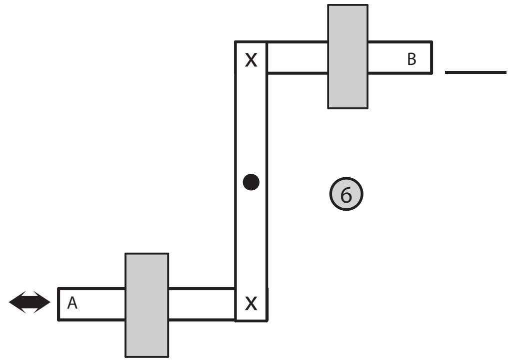
Legend



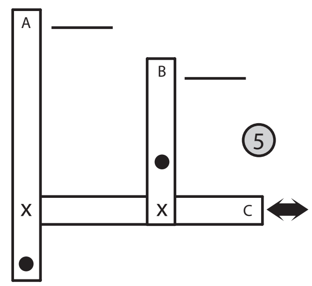
For this *Exploration*, your instructor will assign you to a two-person team.

Study the linkage configurations found in Figure 1. Beside each linkage, write the predicted direction(s) for the various points in the system as you pull or push each linkage configuration at point A.

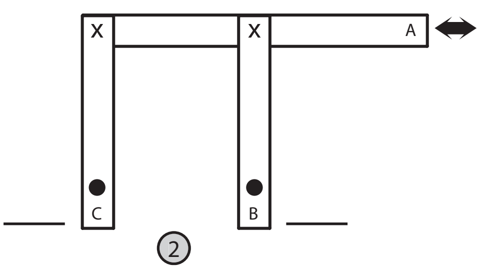
Figure 1. Linkage configurations and predicted movements



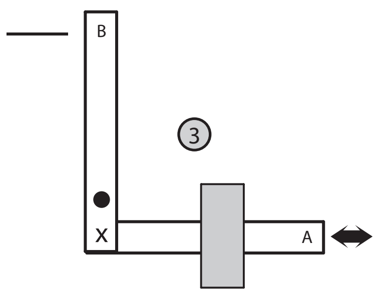
When Point A is pulled to the left, B will move to the right.



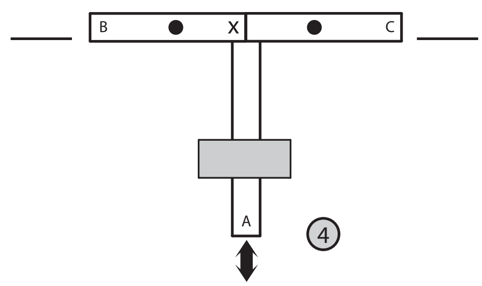
When Point C is pulled to the right, B and A will turn inward. If C goes to the left, B and A turn outward.



When Point A is pulled to the left, both B and C will move to the right.



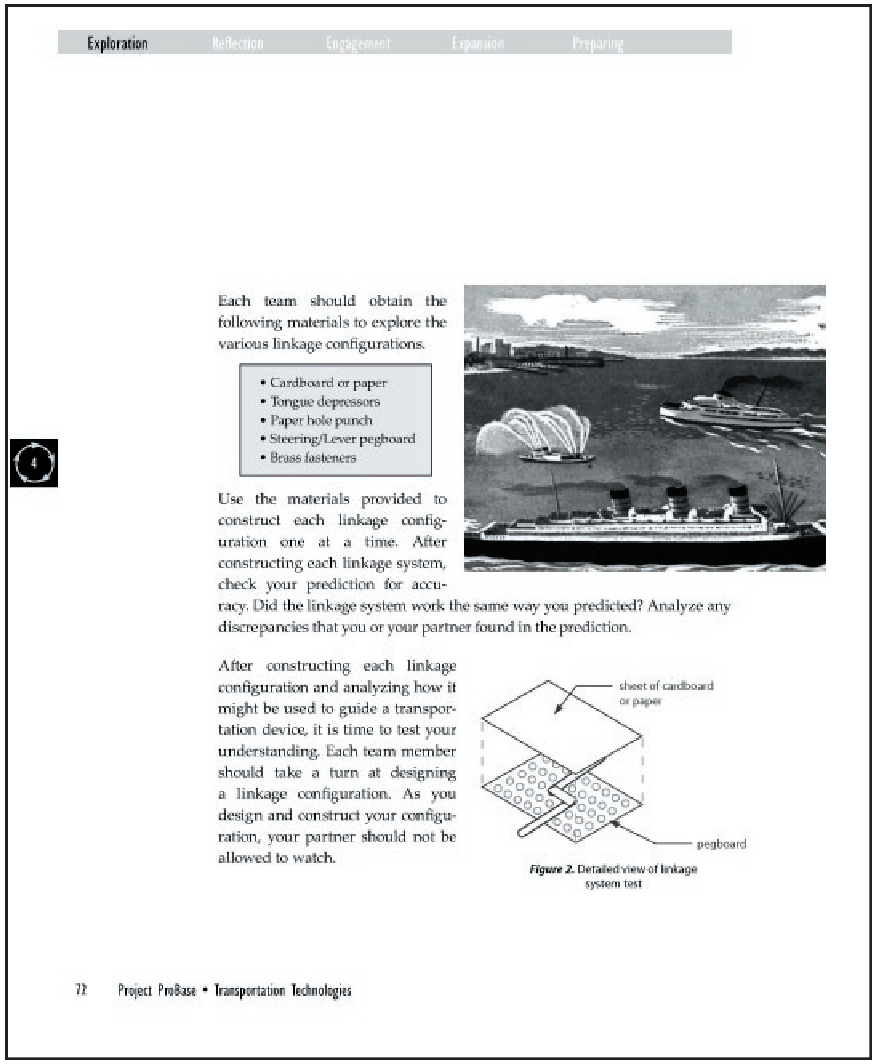
When Point A is pulled to the left, B will move to the left.



When Point A is pulled down, B and C will turn up. If A goes up, B and C turn down.

Teaching Tips

After students have constructed each linkage configuration and analyzed how it might be used to guide a transportation device, they should test their understanding. Each team member should take a turn at designing a different linkage configuration.



Exploration Reflection Engagement Expansion Preparing

Each team should obtain the following materials to explore the various linkage configurations.

- Cardboard or paper
- Tongue depressors
- Paper hole punch
- Steering/Lever pegboard
- Brass fasteners

Use the materials provided to construct each linkage configuration one at a time. After constructing each linkage system, check your prediction for accuracy. Did the linkage system work the same way you predicted? Analyze any discrepancies that you or your partner found in the prediction.

After constructing each linkage configuration and analyzing how it might be used to guide a transportation device, it is time to test your understanding. Each team member should take a turn at designing a linkage configuration. As you design and construct your configuration, your partner should not be allowed to watch.

sheet of cardboard or paper

pegboard

Figure 2. Detailed view of linkage system test

72 Project ProBase • Transportation Technologies

As students design and construct their configuration, the other member of the team should not be allowed to watch. After constructing the linkage configuration, they should cover the mechanism with paper, cardboard, or other opaque material so that their partner cannot see the configuration.

The moving points should stick beyond the cover so that each partner can observe the input and output movement (see diagram at left). Allow students enough time to test their knowledge of linkages, using two or three different configurations. After each demonstration, the student serving as the witness should attempt to sketch a plausible linkage system that represents the hidden linkage.

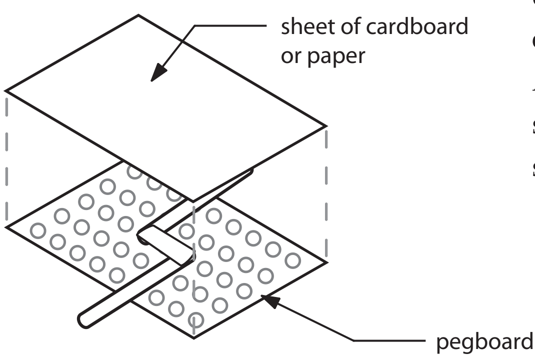
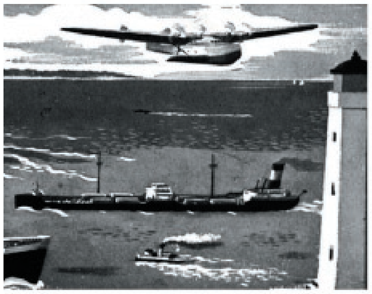


Figure 2. Detailed view of linkage system test



After constructing the linkage configuration, cover the board with paper, cardboard, or another opaque material so that your partner cannot see your configuration (as shown in Figure 2). The moving points should stick beyond the cover so that your partner can observe their movement.

Allow your partner to pull and/or push one of the points of your system and observe what happens to the other exposed point. After your partner observes your configuration, he or she should sketch a plausible linkage system that performs like yours.

After the sketch is completed, you should uncover your system and see how closely your partner's solution matches the configuration. If the solution is different, you should work together to construct the solution and observe how it works. You may find that there is more than one plausible solution to configuring the linkage system.

After one team member has completed this test, the other team member should take her or his turn. If time permits, this should be repeated using different configurations.

When both team members have tested their knowledge of linkage configurations, return all materials to your instructor and write the answers to the *Reflection* questions in the Inventor's Logbook spaces provided.

Remind the other students to sketch a plausible linkage system that performs like their partners'. If students develop solutions that move in the same way that their partners' did using a different configuration, they should construct their solution to be sure that it works like they think it does.

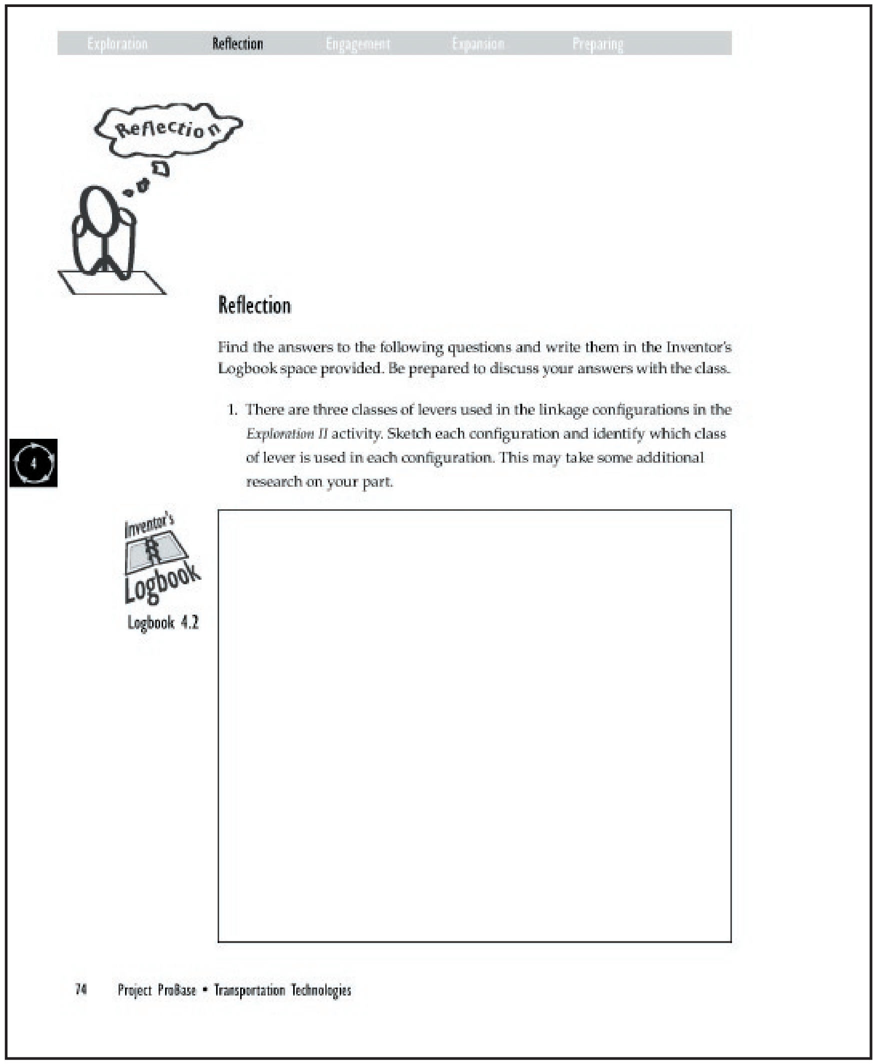
Reflection

Teaching Tips

Students could do this as homework if time is limited. Some students may need to conduct additional research using the Internet or other available resources to find the answers to these questions.

Students are asked to find the answers to the following questions and write them in the Inventor's Logbook spaces provided.

1. There are three classes of levers used in the linkage configurations in the *Exploration II* activity. Students are asked to identify which class of lever is used in each configuration. *See Table 1 for the classes of lever.*


Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

1. There are three classes of levers used in the linkage configurations in the *Exploration II* activity. Sketch each configuration and identify which class of lever is used in each configuration. This may take some additional research on your part.

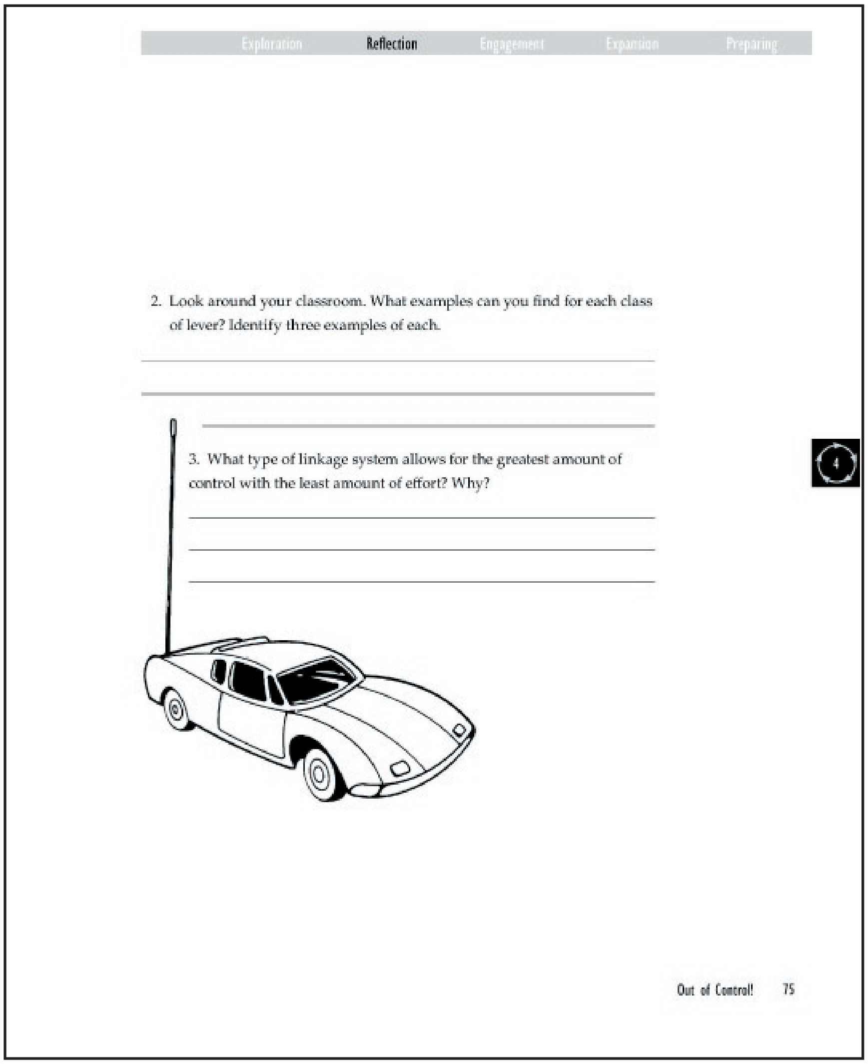
Inventor's Logbook

Logbook 4.2

74 Project ProBase • Transportation Technologies

Table 1.
Lever classes for *Exploration* configurations

Configuration	Class of Lever
1	1-1st class
2	2-2nd class
3	1-1st class
4	2-1st class
5	1-1st class; 1-3rd class
6	1-1st class


Exploration Reflection Engagement Expansion Preparing

2. Look around your classroom. What examples can you find for each class of lever? Identify three examples of each.

3. What type of linkage system allows for the greatest amount of control with the least amount of effort? Why?

4

Out of Control! 75

2. Look around your classroom. What examples can you find for each class of lever? Students are asked to identify three examples of each.
   Examples will come from your class and may include things like the door.

3. What type of linkage system allows for the greatest amount of control with the least amount of effort? Why?
   A first-class lever, because the fulcrum can be changed to various positions to adjust the amount of control necessary and the amount of effort used.

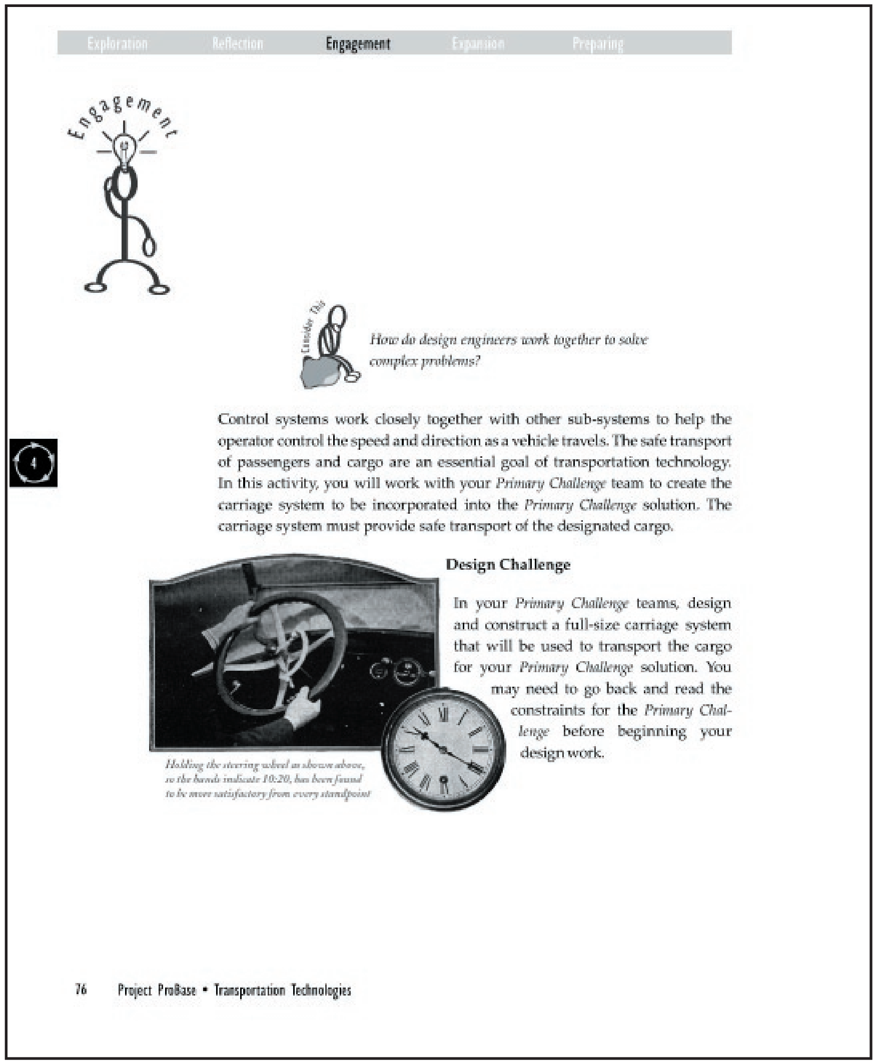
Engagement

The *Engagement* phase of this learning cycle allows students to apply what they have explored about linkage systems as they design and construct a prototype carriage system. This carriage system may be used to provide the safe transit of the cargo for the *Primary Challenge.*

Teaching tips

Allow students to work in their *Primary Challenge* teams for this activity.

Students are asked to design a carriage system. Encourage your students to read the constraints for the *Primary Challenge* before beginning this task. Their systems may be separate from the vehicle design (i.e., a trailer or side car) or incorporated into a uni-body vehicle design.



Engagement

Consider This

How do design engineers work together to solve complex problems?

Control systems work closely together with other sub-systems to help the operator control the speed and direction as a vehicle travels. The safe transport of passengers and cargo are an essential goal of transportation technology. In this activity, you will work with your *Primary Challenge* team to create the carriage system to be incorporated into the *Primary Challenge* solution. The carriage system must provide safe transport of the designated cargo.

Design Challenge

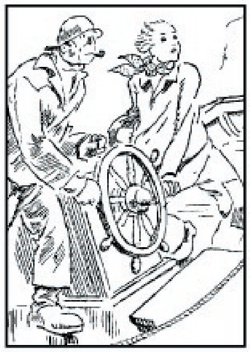
In your *Primary Challenge* teams, design and construct a full-size carriage system that will be used to transport the cargo for your *Primary Challenge* solution. You may need to go back and read the constraints for the *Primary Challenge* before beginning your design work.

Holding the steering wheel as shown above, so the hands indicate 10:20, has been found to be more satisfactory from every standpoint

Student teams should work under the following criteria/ constraints as stated in the student text:

Criteria/Constraints

1. Your carriage system must be full size.
2. You must have a way to attach this carriage system to the final vehicle.



Criteria/Constraints

1. Your carriage system must be full size.
2. You must have a way to attach the carriage system to the final vehicle.
3. Your team will need to present your carriage system to the rest of the class and explain how it works.
4. To get started:
   a. Sketch two to three different designs on a separate sheet of paper.
   b. Select a design.
   c. Create a materials list and submit the list to your instructor.
   d. Begin construction.

Teaching Tips

Students may not have enough time to actually construct their carriage systems. They should at least present their designs and turn in a materials list. This will help prepare them for the *Primary Challenge* solution.

3. Your team will need to present the carriage system to the rest of the class and explain how it works.

4. To get started:
   a. Sketch two to three different designs on a separate sheet of paper.
   b. Select a design.
   c. Create a materials list and submit the list to your instructor.
   d. Begin construction.

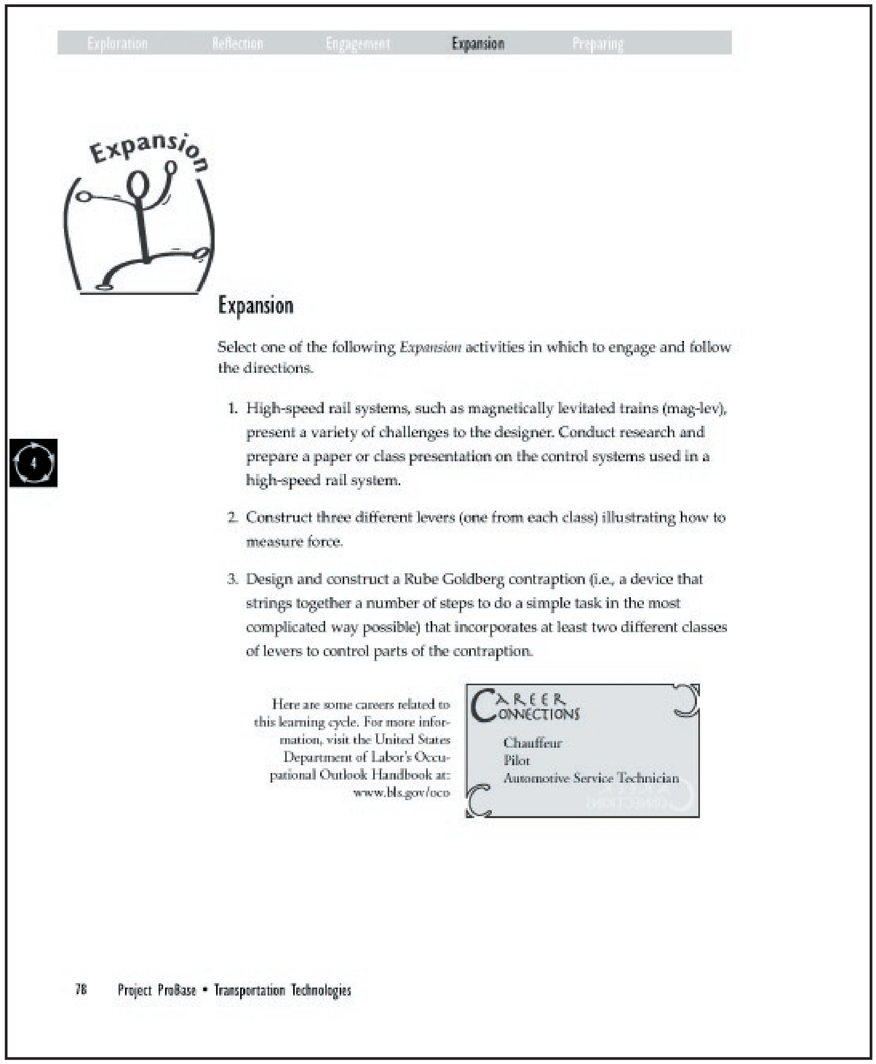
Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explained in this learning cycle.

1. High-speed rail systems, such as magnetically levitated trains (mag-lev), present a variety of challenges to the designer. Conduct research and prepare a paper or class presentation on the control systems in a high-speed rail system.

2. Construct three different levers (one from each class) illustrating how to measure force.

3. Design and construct a Rube Goldberg contraption (i.e., a device that strings together a number of steps to do a simple task in the most complicated way possible) that incorporates at least two different classes of levers to control parts of the contraption.


Exploration Reflection Engagement Expansion Preparing

Expansion

Select one of the following *Expansion* activities in which to engage and follow the directions.

1. High-speed rail systems, such as magnetically levitated trains (mag-lev), present a variety of challenges to the designer. Conduct research and prepare a paper or class presentation on the control systems used in a high-speed rail system.

2. Construct three different levers (one from each class) illustrating how to measure force.

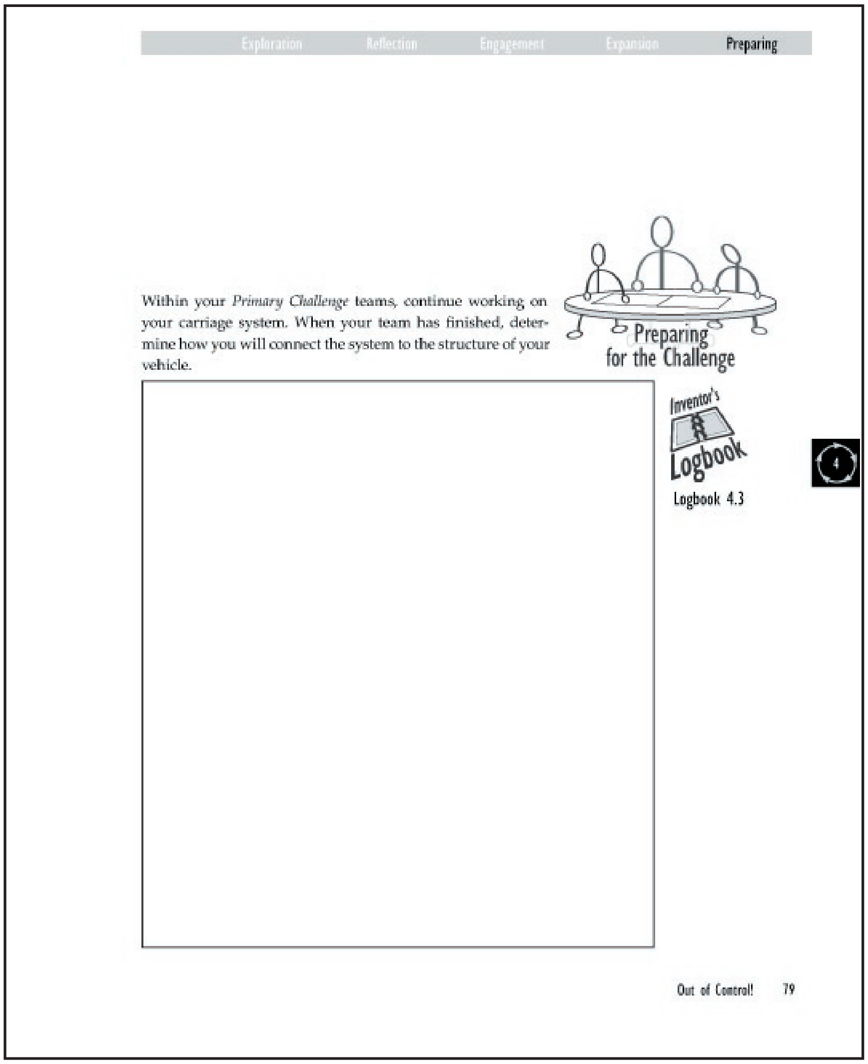
3. Design and construct a Rube Goldberg contraption (i.e., a device that strings together a number of steps to do a simple task in the most complicated way possible) that incorporates at least two different classes of levers to control parts of the contraption.

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

CAREER CONNECTIONS

Chauffeur
Pilot
Automotive Service Technician

78 Project ProBase • Transportation Technologies


Exploration Reflection Engagement Expansion **Preparing**

Within your *Primary Challenge* teams, continue working on your carriage system. When your team has finished, determine how you will connect the system to the structure of your vehicle.

Out of Control! 79

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

Preparing for the Challenge

Students are asked to meet with their *Primary Challenge* team to continue working on their steering system. If some groups have completed their system, they should be directed to determine how they will connect it to the structure of their vehicle.

Out of Control!

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Research Research	Exceptional amount of research conducted about historical devel-opments of brake system.	Above average amount of research conducted about historical devel-opments of brake system.	Average amount of research conducted about historical developments of brake system.	Limited research conducted on brake system.	
Documentation	Exceptional docu-mentation of research; more than 10 logbook entries/ sketches.	Above average documentation of research; 7-9 logbook entries/ sketches.	Average documen-tation of research; 4-6 logbook entries/ sketches.	Below average documentation of research; 1-3 logbook entries/ sketches.	
Presentation and Communication Preparation	Exceptional preparation of presentation with strong visual aids/ appropriate technology.	Above average preparation of presentation with good visual aids/ appropriate technology.	Average preparation of presentation with basic visual aids/ appropriate technology.	Below average preparation of presentation.	
Effectiveness	Presentation was exceptionally effec-tive, clear, and accurate.	Presentation was effective, clear, and accurate.	Presentation's effec-tiveness, clarity, and accuracy were average.	Presentation's effectiveness, clarity, and accu-racy were below average.	
Informative and Interesting	Presentation was exceptionally infor-mative and interesting.	Presentation was highly informative and interesting.	Presentation was informative and interesting.	Presentation was neither informative nor interesting.	
Design Carriage system	Exceptional creativity and inno-vation in design.	Above average creativity and inno-vation in design.	Average creativity and innovation in design.	Below average creativity and innovation in design.	
Inventor's Logbook Entries	Fully answered all entries and provided good examples.	Answered 80% of the entries and provided some examples.	Answered 70% of the entries and provided few examples.	Did not answer entries and did not provide examples.	
				Total Points	

4

Learning Cycle Five

Ready, Set, GO!

Ready, Set, GO!

Introduction

The goal for this learning cycle is to have students explore the concept of torque and gear trains. They will begin to understand gear ratios and how to increase and decrease the torque of a small electric motor. After completing this learning cycle, students will be ready to work for the remainder of the nine-week period on their solutions to the *Primary Challenge.*

Objectives and Essential Questions

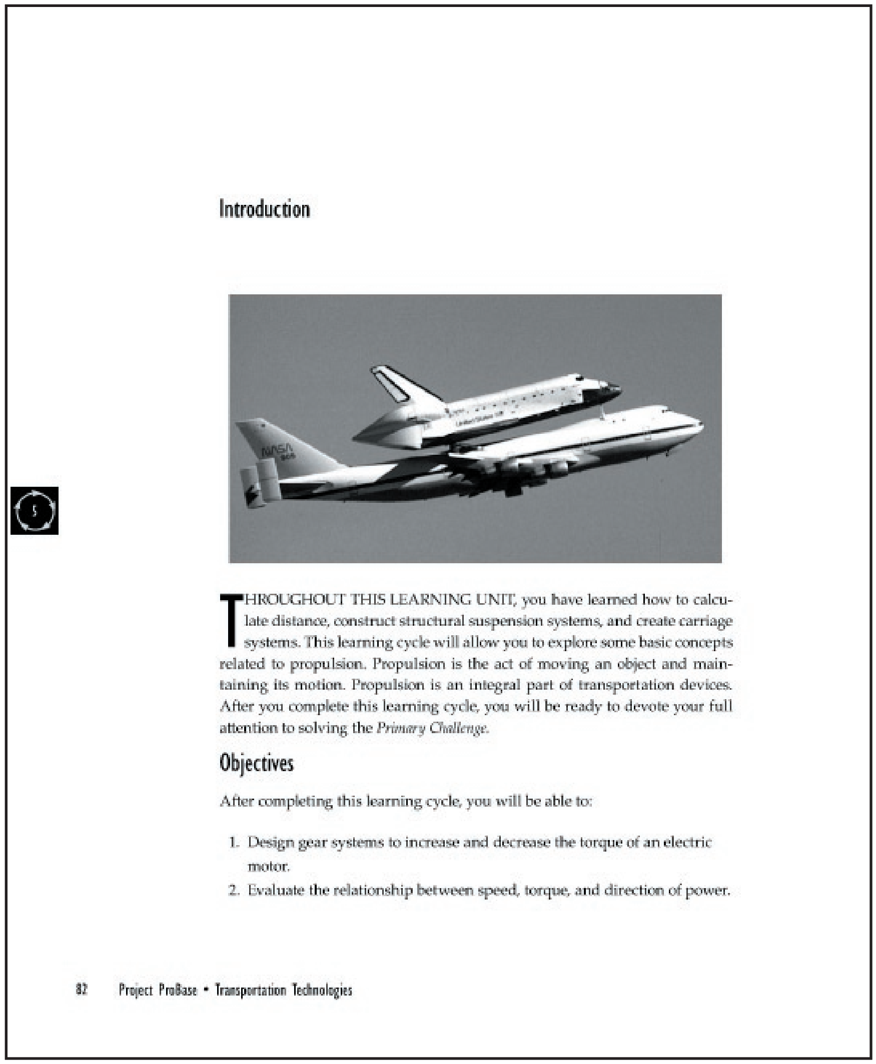
After completing this learning cycle, students will be able to:

1. Design gear systems to increase and decrease the torque of an electric motor.

   Essential Question 9a: How are technologies used to control devices or systems and provide information to humans?

2. Evaluate the relationship between speed, torque, and direction of power.

   Essential Question 7f: How can the establishment of relationships, controlling variables, categorizing techniques, and making inferences aid in the development of new technological designs?



Introduction

THROUGHOUT THIS LEARNING UNIT, you have learned how to calculate distance, construct structural suspension systems, and create carriage systems. This learning cycle will allow you to explore some basic concepts related to propulsion. Propulsion is the act of moving an object and maintaining its motion. Propulsion is an integral part of transportation devices. After you complete this learning cycle, you will be ready to devote your full attention to solving the *Primary Challenge.*

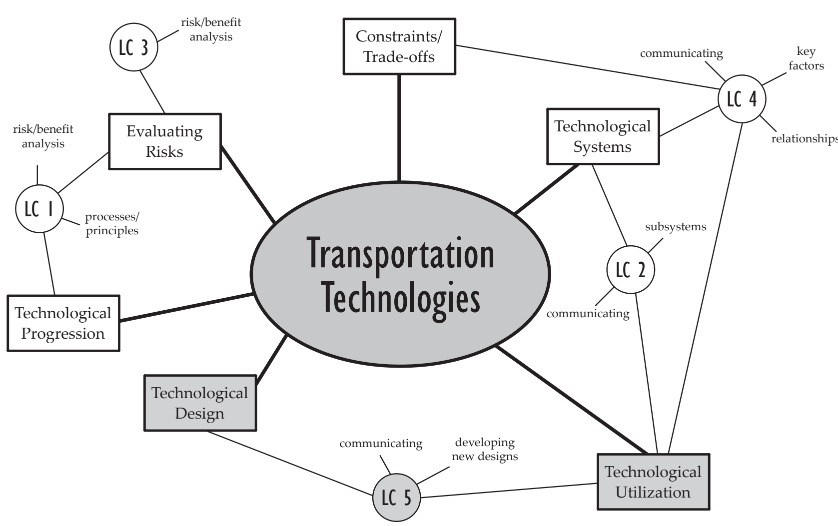
Objectives

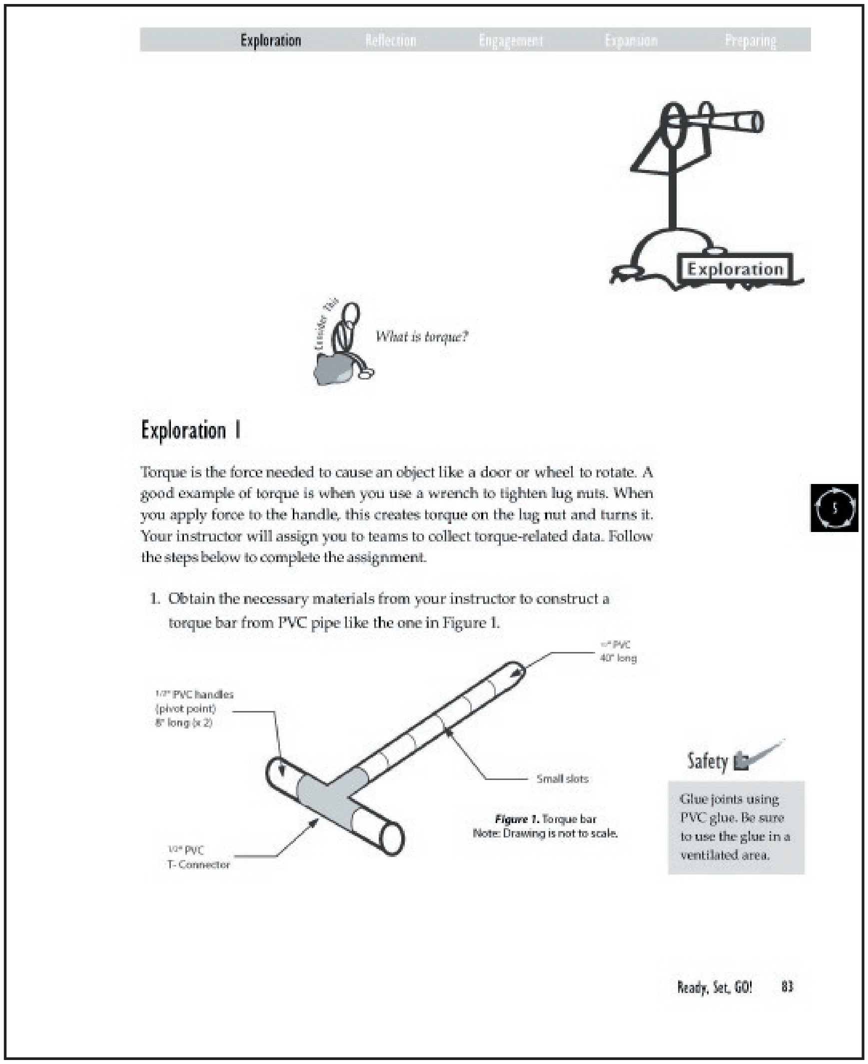
After completing this learning cycle, you will be able to:

1. Design gear systems to increase and decrease the torque of an electric motor.
2. Evaluate the relationship between speed, torque, and direction of power.

82 Project ProBase • Transportation Technologies

Transportation Technologies
Learning Cycle Five Concept Map




Exploration Reflection Engagement Expansion Preparing

Exploration I

Torque is the force needed to cause an object like a door or wheel to rotate. A good example of torque is when you use a wrench to tighten lug nuts. When you apply force to the handle, this creates torque on the lug nut and turns it. Your instructor will assign you to teams to collect torque-related data. Follow the steps below to complete the assignment.

1. Obtain the necessary materials from your instructor to construct a torque bar from PVC pipe like the one in Figure 1.

Figure 1. Torque bar
Note: Drawing is not to scale.

Safety

Glue joints using PVC glue. Be sure to use the glue in a ventilated area.

Ready, Set, GO! 83

Facility Requirements

Explorations I and *II* work best in classrooms with tables large enough to allow students to work in small teams. The *Engagement* activity works best in a general laboratory equipped with basic tools and equipment such as hand tools, drill press, table saw, band saw, etc.

Equipment and Materials

Based on a class of 28 students:

45 feet of ½" PVC pipe

(9) ½" PVC T-connectors

Hack saw

1,000 gram weight (e.g., bucket of water or sand, stack of metal washers)

PVC glue

(9) Gear Box and Motor Kits - providing multiple gear box configurations

(9) AA batteries

(9) AA battery holders

(38) Wheels – 1⅝" diameter

(38) Wheels – 3" diameter

(9) Slide switches - 0.5A DC/3A AC - 36" of 1⅛" welding rod for wheel axles

(9) ¼" eye screws

(9) Spring scales (with a capacity of 5 Newtons)

Various materials specified by design solutions in the *Engagement* activity.

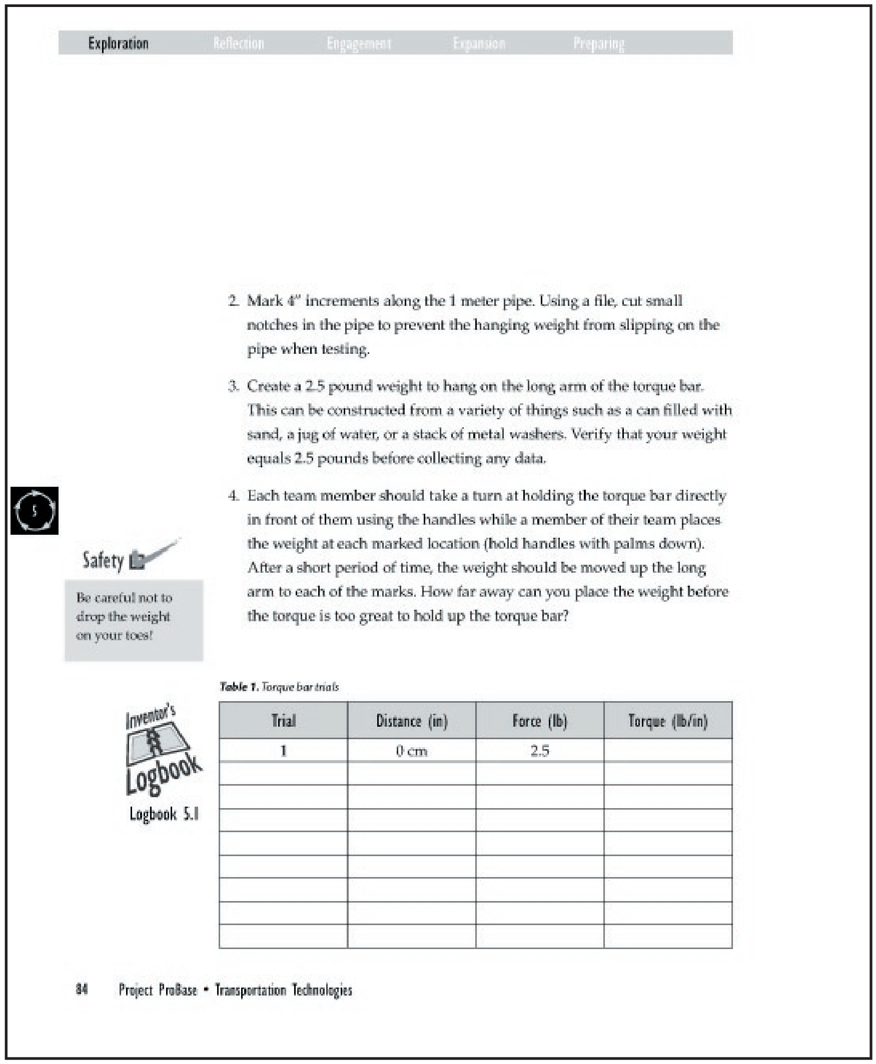
5

Suggested Daily Outline

Day One	Day Two
Introduction, *Exploration I*	*Exploration I* *Reflection*
Day Three	**Day Four**
Exploration II	*Exploration II* *Reflection*
Day Five	**Day Six**
Engagement	*Engagement*

5

Estimated Number of 50-minute class periods: **6**


Exploration Reflection Engagement Expansion Preparing

2. Mark 4" increments along the 1 meter pipe. Using a file, cut small notches in the pipe to prevent the hanging weight from slipping on the pipe when testing.

3. Create a 2.5 pound weight to hang on the long arm of the torque bar. This can be constructed from a variety of things such as a can filled with sand, a jug of water, or a stack of metal washers. Verify that your weight equals 2.5 pounds before collecting any data.

4. Each team member should take a turn at holding the torque bar directly in front of them using the handles while a member of their team places the weight at each marked location (hold handles with palms down). After a short period of time, the weight should be moved up the long arm to each of the marks. How far away can you place the weight before the torque is too great to hold up the torque bar?

Safety

Be careful not to drop the weight on your toes!

Inventor's Logbook

Logbook 5.1

Table 1. Torque bar trials

Trial	Distance (in)	Force (lb)	Torque (lb/in)
1	0 cm	2.5	

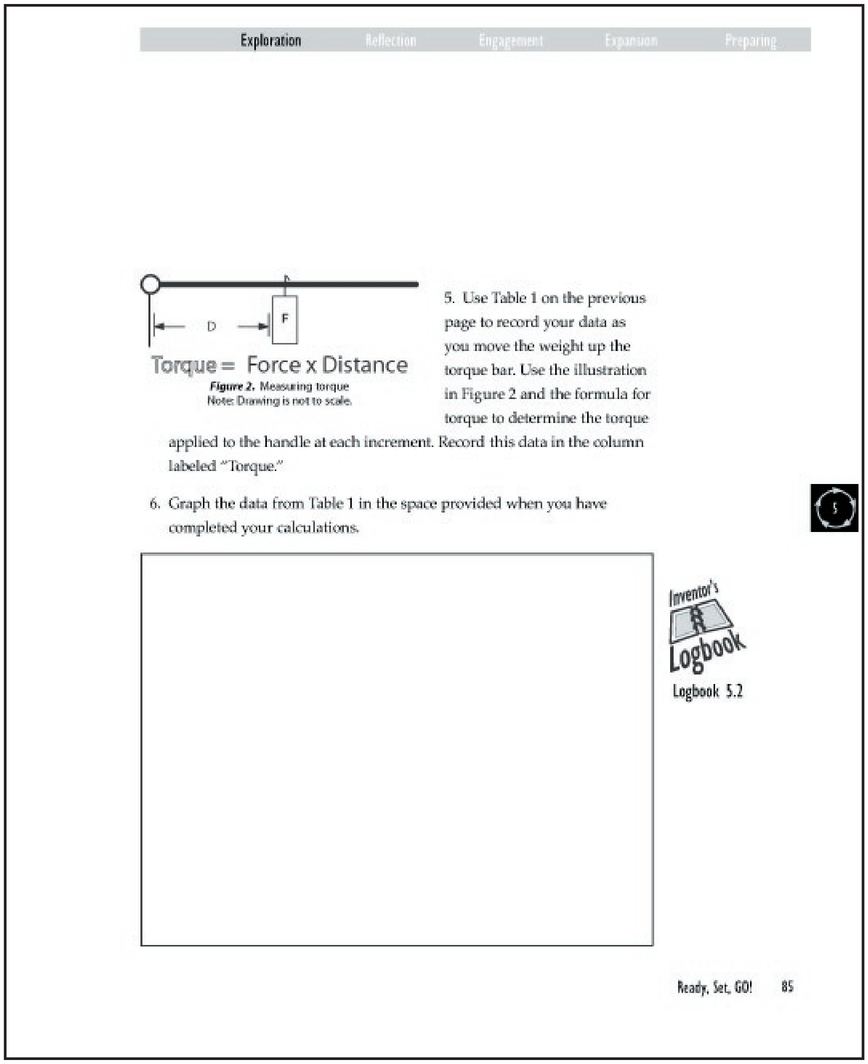
84 Project ProBase • Transportation Technologies

Exploration I

The *Exploration I* phase has the students construct a device (Figure 1) that will allow them to kinesthetically experience the concept of torque.

Teaching tips

Assign students to small teams of three or four and allow them to construct the torque bar following the illustration in the student text. Encourage each student to experience this activity. Remind students to record the data in Table 1 in the student text.



Exploration Reflection Engagement Expansion Preparing

Torque = Force x Distance

Figure 2. Measuring torque
Note: Drawing is not to scale.

5. Use Table 1 on the previous page to record your data as you move the weight up the torque bar. Use the illustration in Figure 2 and the formula for torque to determine the torque applied to the handle at each increment. Record this data in the column labeled "Torque."

6. Graph the data from Table 1 in the space provided when you have completed your calculations.

Inventor's Logbook

Logbook 5.2

Ready, Set, GO! 85

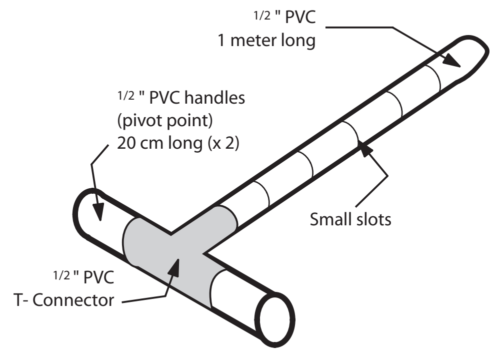


Figure 1. Torque bar
Note: Drawing is not to scale.

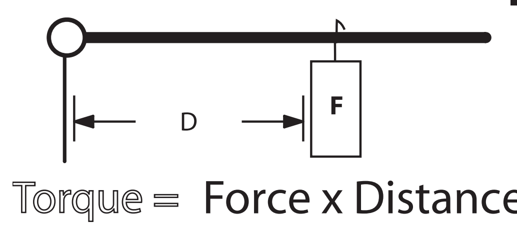
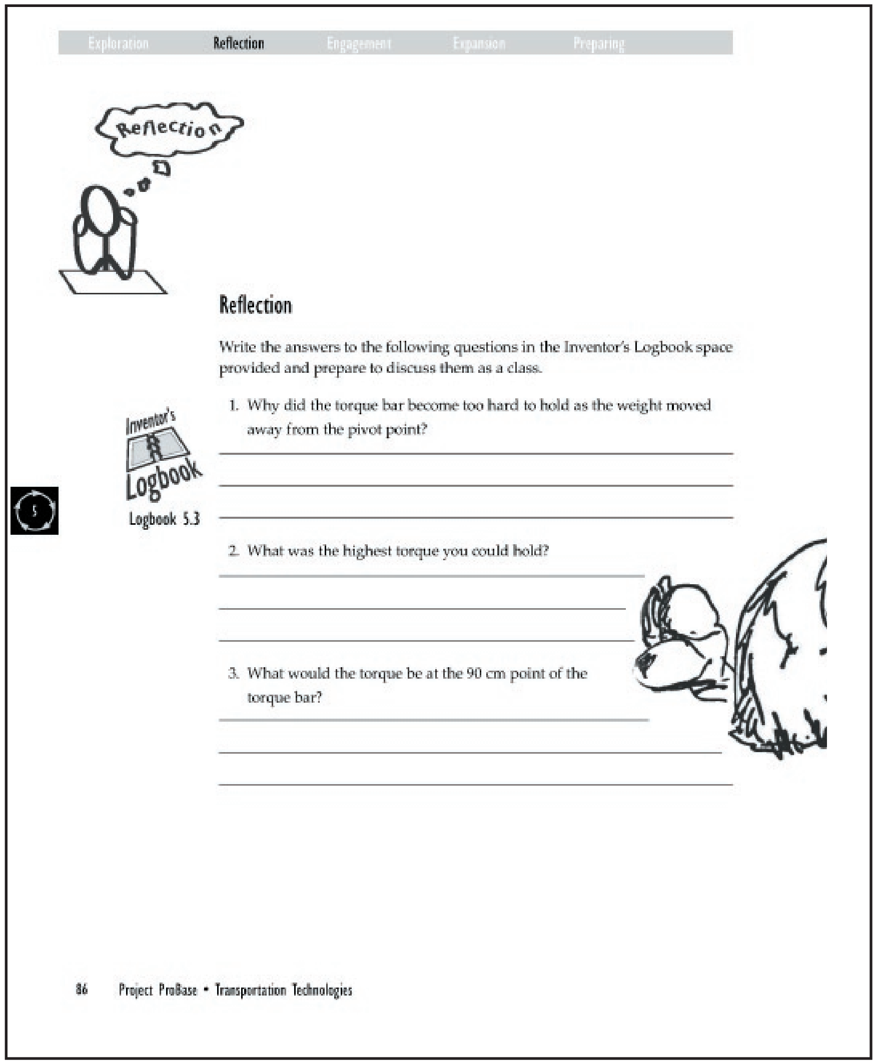


Figure 2. Measuring torque
Note: Drawing is not to scale.

Table 1.
Torque bar trials

Trial	Distance (cm)	Force (g)	Torque (g.cm)
1	0 cm	1000	


Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

Write the answers to the following questions in the Inventor's Logbook space provided and prepare to discuss them as a class.

Inventor's Logbook

Logbook 5.3

1. Why did the torque bar become too hard to hold as the weight moved away from the pivot point?

2. What was the highest torque you could hold?

3. What would the torque be at the 90 cm point of the torque bar?

86 Project ProBase • Transportation Technologies

Reflection

Students are asked to write the answers to the following questions in the Inventor's Logbook spaces provided and be prepared to discuss them as a class.

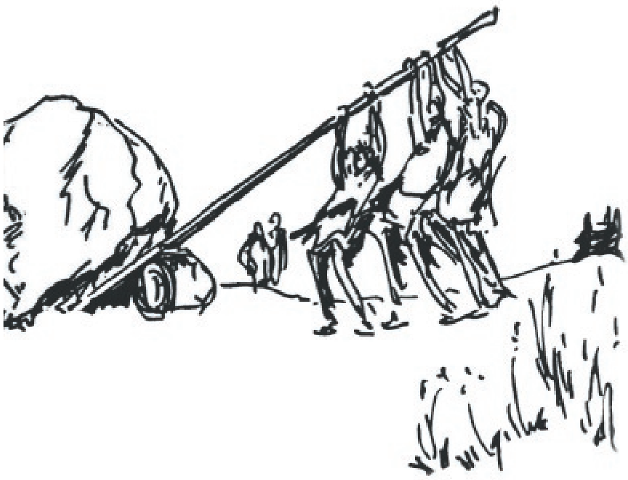
1. Why did the torque bar become too hard to hold up as the weight moved away from the pivot point?
   Because torque increases as the distance increases ($T = fd$).

2. What was the highest torque you could hold up?
   Student answers will vary.

3. What would the torque be at the 90 cm point of the torque bar?
   90,000 g.cm

4. What would the torque be at 2 meters if you could extend the torque bar?
   200,000 g.cm

4. What would the torque be at 2 meters if you could extend the torque bar?



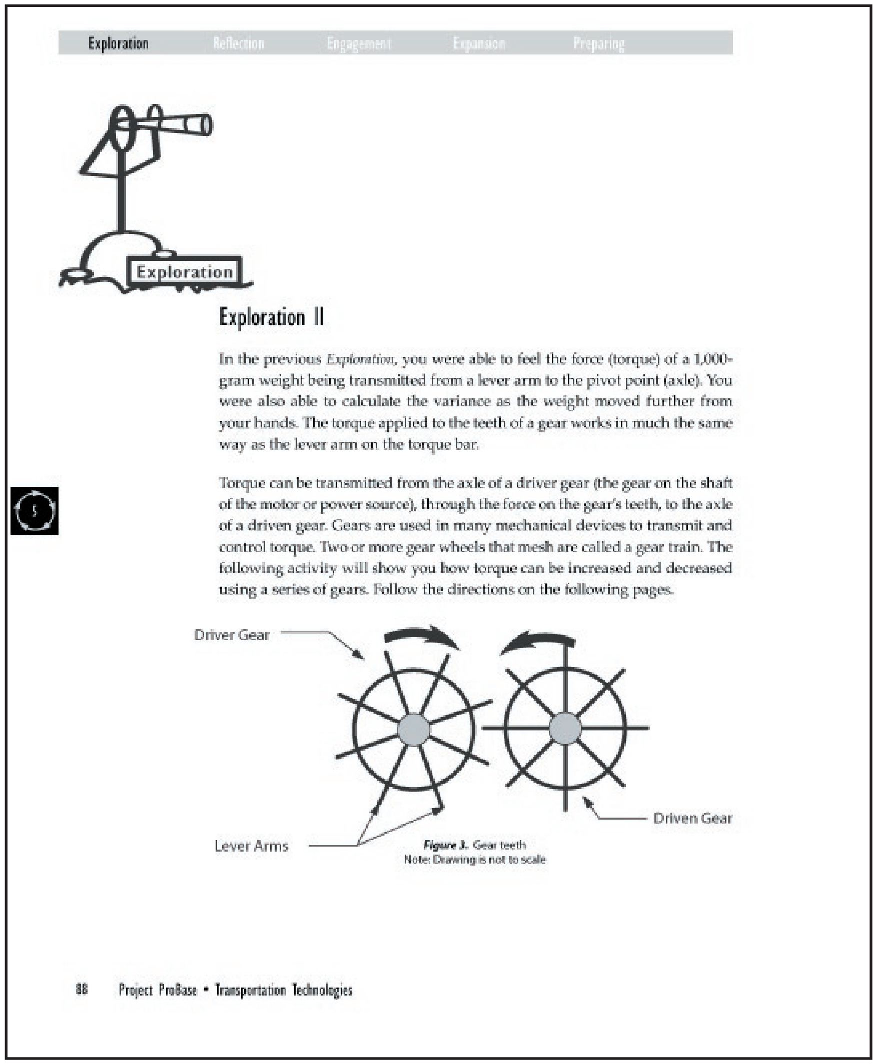
Notes:

Exploration II

In *Exploration II,* students explore torque as it relates to gear trains using a gear box kit.

Teaching tips

Students are provided directions for assembling several gear trains and for calculating the torque for each arrangement. Assign your students to three-person teams. Remove the directions from the gear box kits and photocopy the front page only. Provide this as reference material for the teams. The directions on the front page will provide the necessary information for them to put the gear box together.


Exploration Reflection Engagement Expansion Preparing

Exploration

Exploration II

In the previous *Exploration*, you were able to feel the force (torque) of a 1,000-gram weight being transmitted from a lever arm to the pivot point (axle). You were also able to calculate the variance as the weight moved further from your hands. The torque applied to the teeth of a gear works in much the same way as the lever arm on the torque bar.

Torque can be transmitted from the axle of a driver gear (the gear on the shaft of the motor or power source), through the force on the gear's teeth, to the axle of a driven gear. Gears are used in many mechanical devices to transmit and control torque. Two or more gear wheels that mesh are called a gear train. The following activity will show you how torque can be increased and decreased using a series of gears. Follow the directions on the following pages.

Driver Gear

Driven Gear

Lever Arms

Figure 3. Gear teeth
Note: Drawing is not to scale

88 Project ProBase • Transportation Technologies

The motors will not be used until the *Engagement* activity. You may want to put these away in a secure area until they are needed.

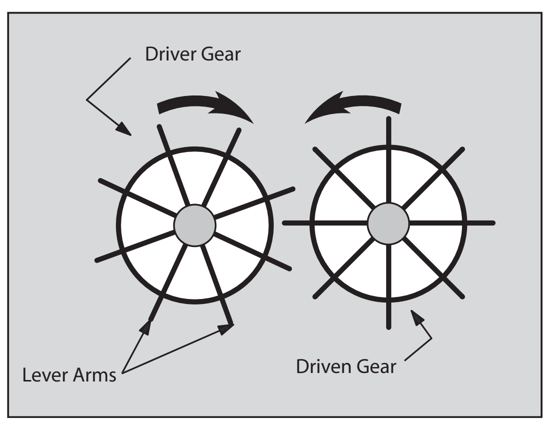


Figure 3. Gear teeth
Note: Drawing is not to scale

1. Create the gear train illustrated in Figure 3 using two gears of the same size and the gear box plates provided in your gear box kit.

$$\text{Gear Ratio} = \frac{\text{Turns of Driven Gear}}{\text{Turns of Driver Gear}} = \frac{\text{Teeth of Driven Gear}}{\text{Teeth of Driver Gear}}$$

Figure 4. Formula for calculating gear ratio

2. Use the formula found in Figure 4 to calculate the gear ratio for this setup. Mark a spot on the gear as a reference point and turn the driver gear one full revolution. Count the number of times the driven gear turns. Record this information in the Inventor's Logbook space provided.

Inventor's Logbook

Logbook 5.4

Notes:

$$\text{Gear Ratio} = \frac{\text{Turns of Driven Gear}}{\text{Turns of Driver Gear}} = \frac{\text{Teeth of Driven Gear}}{\text{Teeth of Driver Gear}}$$

Figure 4. Formula for calculating gear ratio

Notes:

Exploration Reflection Engagement Expansion Preparing

3. Use one grey gear, one red gear, and gear box plates to set up a similar configuration. Sketch this configuration in the Inventor's Logbook space provided. Calculate the gear ratio and record the ratio in the Inventor's Logbook space provided. Turn the driver gear one full revolution and count the number of times that the driven gear turns. Record this information below.

Inventor's Logbook

Logbook 5.5

The example in Figure 5 has three gears meshed together. Each place where the gears mesh defines a gear ratio. One gear has 10 teeth, one has 50 teeth and one has 30 teeth. This gear train ratio can be calculated in a variety of ways. For example, the formula in Figure 4 can be used to calculate the gear ratio by following these steps:

a. Write a gear ratio fraction that represents each pair of meshing gears

A:B = $\frac{50}{10}$ B:C = $\frac{30}{50}$

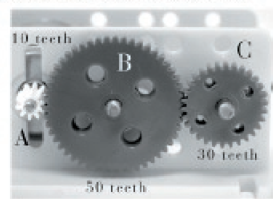
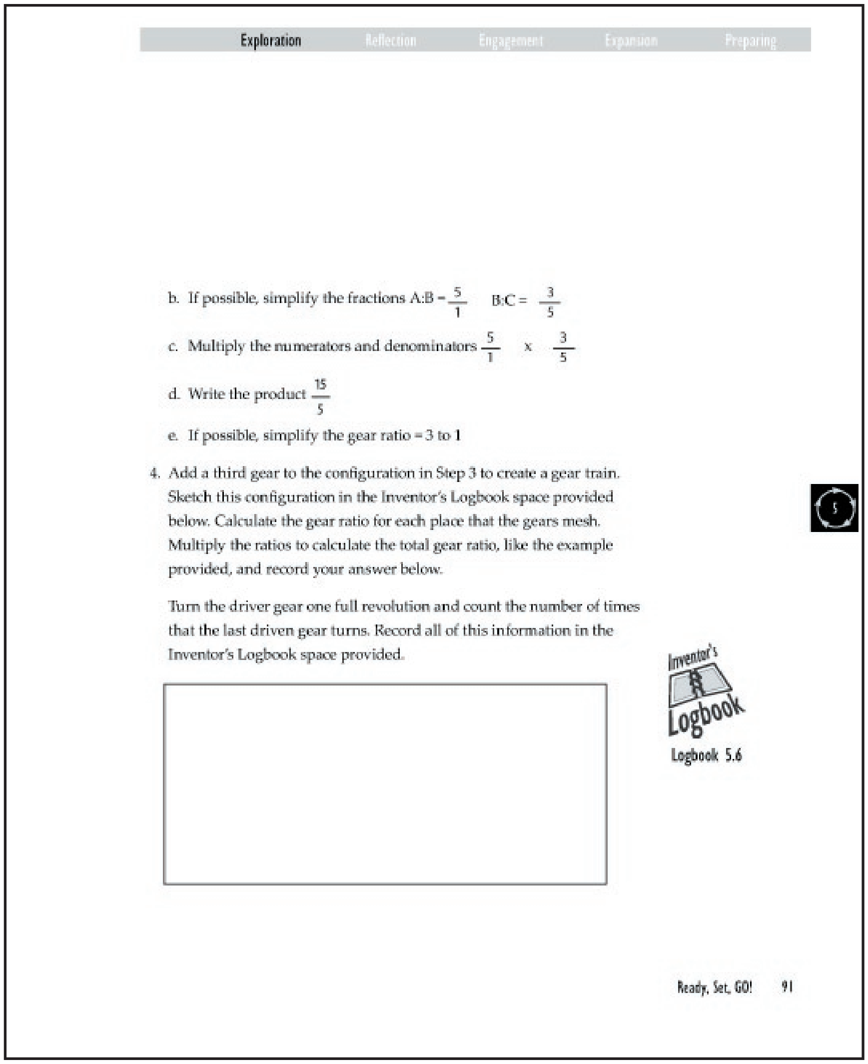


Figure 5. 3-gear configuration

90 Project ProBase • Transportation Technologies



Exploration Reflection Engagement Expansion Preparing

b. If possible, simplify the fractions A:B = $\frac{5}{1}$ B:C = $\frac{3}{5}$

c. Multiply the numerators and denominators $\frac{5}{1}$ x $\frac{3}{5}$

d. Write the product $\frac{15}{5}$

e. If possible, simplify the gear ratio = 3 to 1

4. Add a third gear to the configuration in Step 3 to create a gear train. Sketch this configuration in the Inventor's Logbook space provided below. Calculate the gear ratio for each place that the gears mesh. Multiply the ratios to calculate the total gear ratio, like the example provided, and record your answer below.

Turn the driver gear one full revolution and count the number of times that the last driven gear turns. Record all of this information in the Inventor's Logbook space provided.

Inventor's Logbook

Logbook 5.6

Ready, Set, GO! 91

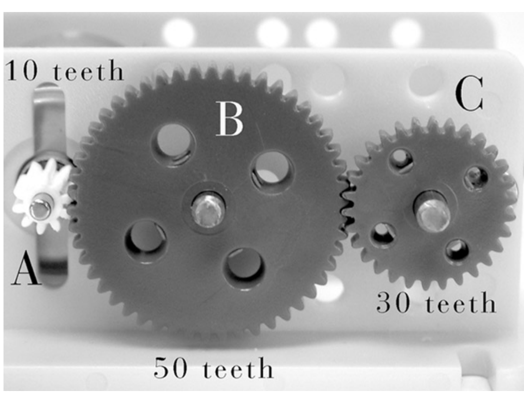


Figure 5. 3-gear configuration

a. Write a gear ratio fraction that represents each pair of meshing gears.

A:B = $\frac{50}{10}$ B:C = $\frac{30}{50}$

b. If possible, simplify the fractions.

A:B = $\frac{5}{1}$ B:C = $\frac{3}{5}$

c. Multiply the numerators and denominators.

$\frac{5}{1}$ x $\frac{3}{5}$

d. Write the product.

$\frac{15}{5}$

e. Simplify if possible.

Gear ratio = 3 to 1

5. Take turns among your team members creating different configurations using at least five gears (make sure that each team member creates at least three different configurations). Have your team members:

   a. Predict the final direction that the last driven gear in the gear chain will rotate and then check to determine accuracy.

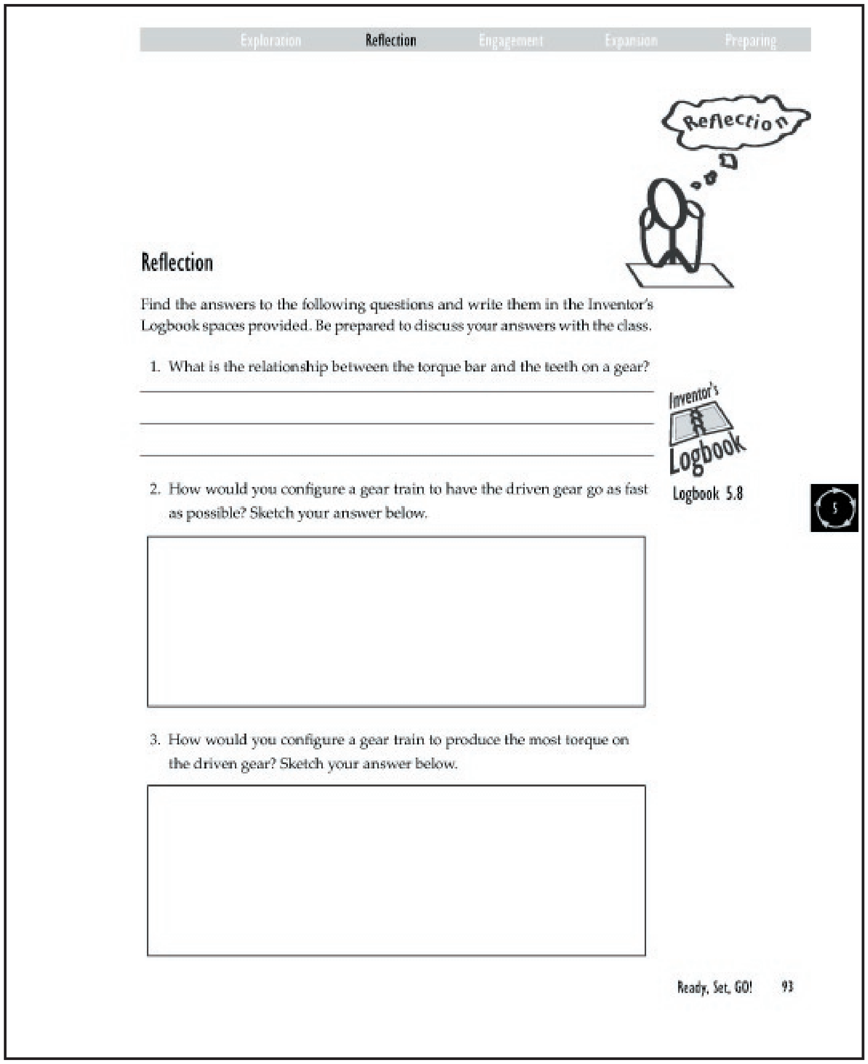
   b. Calculate the total gear ratio for your configuration.

   c. Test predictions by having someone turn the driver gear while observing the last driven gear in the gear chain. How many times did the last driven gear turn for each revolution of the driver gear?

   d. Place your predictions, calculations, and results in the Inventor's Logbook space provided below.

Inventor's Logbook

Logbook 5.7



Exploration Reflection Engagement Expansion Preparing

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Be prepared to discuss your answers with the class.

1. What is the relationship between the torque bar and the teeth on a gear?

Logbook 5.8

2. How would you configure a gear train to have the driven gear go as fast as possible? Sketch your answer below.

3. How would you configure a gear train to produce the most torque on the driven gear? Sketch your answer below.

Ready, Set, GO! 93

Reflection

Students are asked to find the answers to the following questions and write them in the Inventor's Logbook spaces provided.

1. What is the relationship between the torque bar and the teeth on a gear?
   Torque is applied to the teeth of a gear much like it is applied to the torque bar.

2. How would you configure a gear train to have the driven gear go as fast as possible?
   Place the big gear on the motor shaft and have it drive a smaller gear. Students are asked to sketch their solutions.

3. How would you configure a gear train to produce the most torque on the driven gear?
   Place the smallest gear on the motor shaft and drive a series of larger gears. Students are asked to sketch their solutions.

Engagement

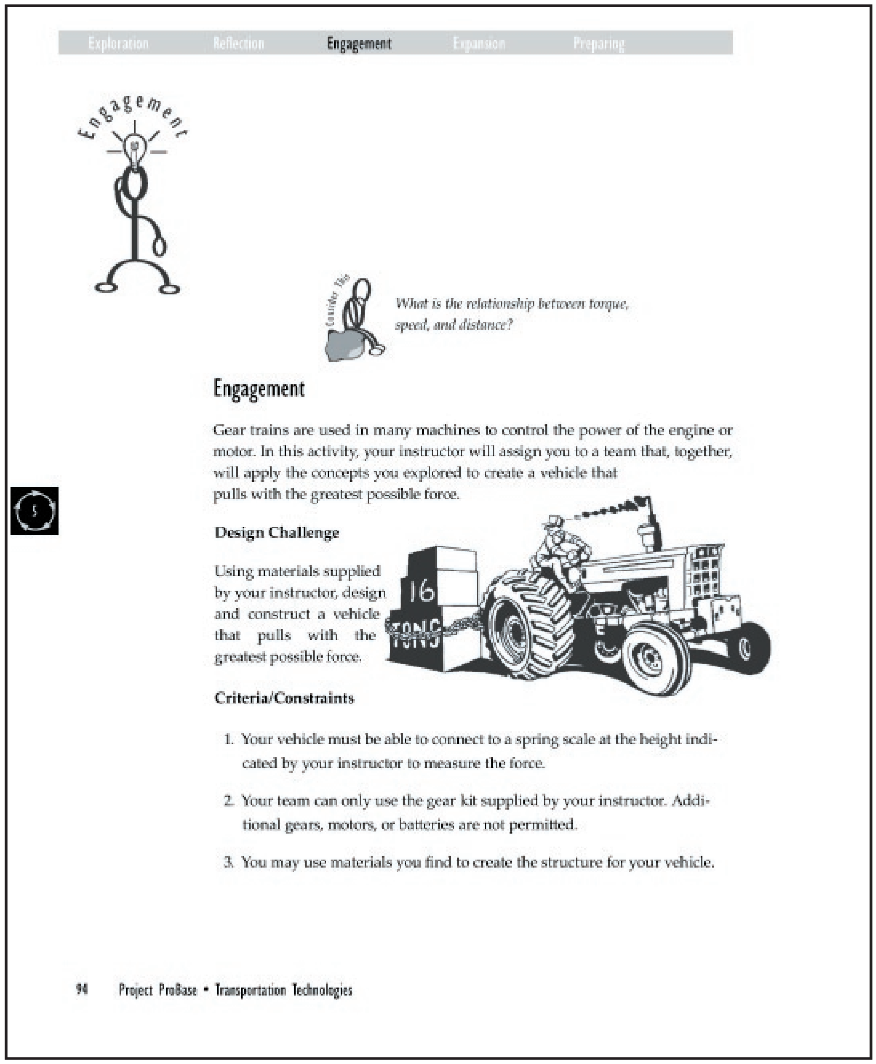
The *Engagement* phase of this learning cycle allows students to apply what they have explored about torque and gear trains as they design and construct a vehicle to pull as much force as possible on a spring scale.

5

Teaching tips

Assign students to teams of three for this design challenge. Students are asked to solve the following design challenge: design and construct a vehicle that pulls the greatest possible force.

Their vehicles must be able to connect to a spring scale at the height that you tell them. You will need to build a small test stand to hold the spring scale. This can be as simple as placing the scale on top of a board clamped to a table. It is important to anchor the spring scale down so that it fairly tests the force pulled by the vehicle.



Exploration Reflection Engagement Expansion Preparing

What is the relationship between torque, speed, and distance?

Engagement

Gear trains are used in many machines to control the power of the engine or motor. In this activity, your instructor will assign you to a team that, together, will apply the concepts you explored to create a vehicle that pulls with the greatest possible force.

Design Challenge

Using materials supplied by your instructor, design and construct a vehicle that pulls with the greatest possible force.

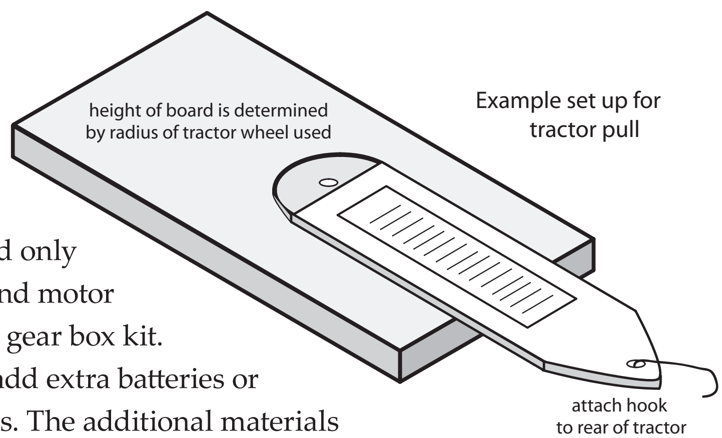
Criteria/Constraints

1. Your vehicle must be able to connect to a spring scale at the height indicated by your instructor to measure the force.
2. Your team can only use the gear kit supplied by your instructor. Additional gears, motors, or batteries are not permitted.
3. You may use materials you find to create the structure for your vehicle.

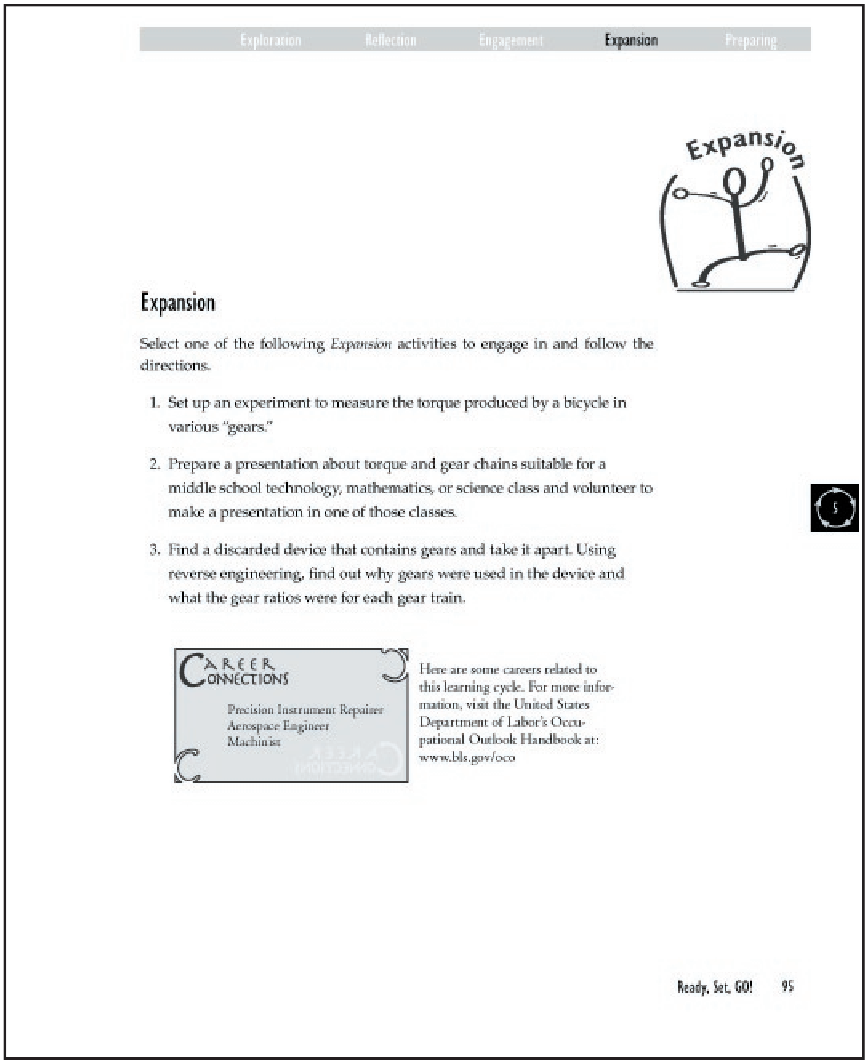
94 Project ProBase • Transportation Technologies

Teaching tips

You may want to simulate a tractor pull competition to find out which team constructed the most powerful vehicle.



Students should only use the gears and motor supplied in the gear box kit. They may not add extra batteries or additional gears. The additional materials needed for the vehicle construction will vary by team. Students should sketch, draw, or use appropriate computer applications to design solutions and prepare a list of required material. Designs and materials lists should be checked before teams begin construction.



Expansion

Select one of the following *Expansion* activities to engage in and follow the directions.

1. Set up an experiment to measure the torque produced by a bicycle in various "gears."
2. Prepare a presentation about torque and gear chains suitable for a middle school technology, mathematics, or science class and volunteer to make a presentation in one of those classes.
3. Find a discarded device that contains gears and take it apart. Using reverse engineering, find out why gears were used in the device and what the gear ratios were for each gear train.

CAREER CONNECTIONS

Precision Instrument Repairer
Aerospace Engineer
Machinist

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

Ready, Set, GO! 95

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

1. Set up an experiment to measure the torque produced by a bicycle in various "gears."

2. Prepare a presentation about torque and gear trains suitable for a middle school technology, mathematics, or science class and volunteer to make a presentation in one of those classes.

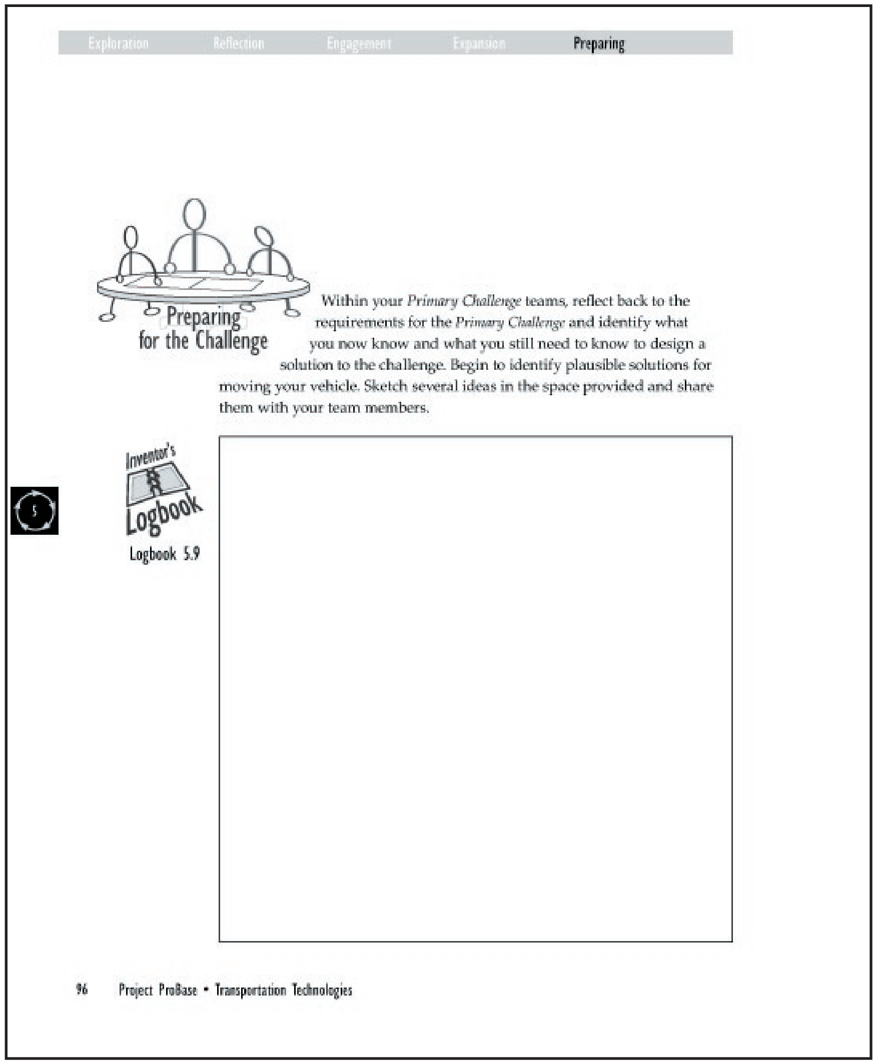
3. Find a discarded device that contains gears and take it apart. Using reverse engineering, find out why gears were used in the device and what the gear ratios were for each gear train.

Preparing for the Challenge

Students are asked to reflect on the requirements of the *Primary Challenge* and identify what questions they now have answers to, and what questions have yet to be answered to solve the *Primary Challenge.* Allow some time for the students to get into their assigned *Primary Challenge* teams and brainstorm possible power sources for their solutions.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.



Exploration Reflection Engagement Expansion **Preparing**

Preparing for the Challenge

Within your *Primary Challenge* teams, reflect back to the requirements for the *Primary Challenge* and identify what you now know and what you still need to know to design a solution to the challenge. Begin to identify plausible solutions for moving your vehicle. Sketch several ideas in the space provided and share them with your team members.

Inventor's Logbook

Logbook 5.9

96 Project ProBase • Transportation Technologies

Ready, Set, Go!

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Design work for Engagement	Exceptional design work to increase vehicle torque.	Above average design work to increase vehicle torque.	Average amount of design work to increase vehicle torque.	Limited design work on vehicle.	
Documentation	Exceptional documentation of design; more than 10 logbook entries/sketches.	Above average documentation of design; 7-9 logbook entries/ sketches.	Average documentation of design; 4-6 logbook entries/ sketches.	Below average documentation of design; 1-3 logbook entries/ sketches.	
Design	Exceptional creativity and innovation in design.	Above average creativity and innovation in design.	Average creativity and innovation in design.	Below average creativity and innovation in design.	
Exploration Torque	Fully identifies and comprehends the concept of torque.	Identifies and comprehends most of the concept of torque.	Identifies and comprehends some of the concept of torque.	Does not identify or comprehend the concept of torque.	
Gear Ratio	Fully identifies and comprehends gear ratios.	Identifies and comprehends most gear ratios.	Identifies and comprehends some gear ratios.	Does not identify or comprehend gear ratios.	
				Total Points	

5

Appendix and Supplemental Materials

Appendix

Appendix

Project ProBase

Enduring Understandings & Essential Questions

Students will understand:

1. that **technological progression** is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.
    a. How are new technologies **developed and marketed**?
    b. What social, cultural, and political **pressures** lead to the need or want for new technologies?
    c. What are the specific **roles of professionals** involved in technological adaptation and change?
    d. What **factors** need to be in place for new technologies to be viable in the national and international marketplace?
    e. What are the fundamental **processes/principles** used to develop new technologies?

2. that **technological** development for the solution of a problem in one context can **spinoff** for use in a variety of often unrelated applications.
    a. How do **technologies migrate** from one context (or location) to another and what are the implications?
    b. What **roles** do the patent, trade-mark, and copyright laws play in the **dissemination of** technological **ideas**?
    c. How have technological innovations caused **paradigm shifts** throughout history and what are these major shifts?

3. that **technological change** can be positive and/or negative, and can have intended and/or unforeseen social, cultural, environmental, and political consequences.
    a. What are some of the unforeseen **consequences** of specific technological changes throughout history?
    b. How can a technology cause both good and harm and how do humans prepare for or respond to these **impacts**?

4. how **technological systems** work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
    a. What are the systems and **subsystems** involved in the various contexts of technology?
    b. What are the key elements of the various technological **systems** and what are the **relationships** between these systems?
    c. How do various technological **systems influence** the economy, society, the environment, and culture?

5. that there are compelling and controversial **issues** associated with the acquisition, development, use, and disposal of **resources**.
    a. What kinds of **resources** are required in each of the eight technological contexts?
    b. What is the **relative value** of specific resources used in technological systems?
    c. To what extent have **resource** issues (acquisition, development, use, and disposal) **affected** the direction of technological **development**?
    d. What **resources** are **needed** to solve a specific design problem (people, information, materials, tools, capital, energy, time, technical ability)?

Students will understand:

6. that the complexities of technological **design** involve **trade-offs** among competing **constraints** and requirements, including engineering, economic, political, social, and environmental considerations.
    a. To what extent have **optimal designs** been achieved in the eight technological context areas?
    b. What are the key **factors** that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems? (**Micro Factors**)
    c. How can members of the public, politicians, or the state of the economy **influence** the design of new technological products and systems? (**Macro Factors**)
    d. How can **social values** and **principles** guide in the development of solutions to technological problems?

7. that **technological design** is a systematic **process** used to initiate and refine ideas, solve problems, and maintain products and systems.
    a. What are the five primary **methods** through which technological **problems** are **solved** and how do they differ (i.e., troubleshooting, research and development, experimentation, invention and innovation, design problem solving)?
    b. To what extent can design problems be approached through a series of generic procedures (the **design loop**)?
    c. What **design criteria** are typically considered when developing new technologies (i.e., marketability, safety, useability, reliability, cost, materials, etc.) and how do these influence the final product/system design?
    d. How are **decisions** made regarding **information** that should be discarded or ignored?
    e. How can the **attributes** of design and the **principles** of design aid in the development of quality solutions?
    f. How can the establishment of relationships, controlling variables, categorizing techniques, and making inferences aid in the **development** of **new** technological **designs**?

8. how to **evaluate** the benefits, limitations, and **risks** associated with existing and proposed technologies.
    a. How does a **risk/benefit analysis** aid the designer in addressing potential harmful effects prior to development?
    b. What are some important **ethical decisions** that should be considered when developing any new technology?
    c. Are all product/system **designs** created for the purpose of adding **social value**?
    d. How are ethical **considerations**, economic considerations, engineering realities, and political forces **balanced** during technological innovation?
    e. In what ways are technological needs and wants being **balanced** with long term environmental or social **consequences**?

9. how to **utilize** a variety of simple and complex **technologies**.
    a. How are technologies used to **control devices** and systems?
    b. How do technologies **communicate** with one another and provide information to humans?
    c. To what extent are technological systems and **devices controlled** by people and to what extent are they controlled by other technologies?
    d. How is technological **instrumentation** used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

Transportation Technologies

Inventor's Logbook

Name: Date: Activity:

What do we know and need to know to solve the Primary Challenge?

Place student questions here

Place student questions here

Transportation Technologies

Students will understand

Enduring Understanding 4: how technological systems work, the compoents of those systems, and how they fit into the larger technological, economic, and social systems.

a. What are the systems and subsystems involved in the various contexts of technology?
b. What are the key elements of the various technological systems and what are the relationships between these systems?
c. How do various technological systems influence the economy, society, the environment and culture?

Enduring Understanding 6: that the complexities of technological design involve tradeoffs among competing constraints and requirements, including engineering, economic, political, social, and environmental considerations.

b. What are the key factors that cause designers to make decisions about tradeoffs, limitations, and constraints when designing new products and systems?
c. How can members of the public, politicians or the state of the economy influence the design of new technological products and systems?

Enduring Understanding 7: that technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.

a. What are the five primary methods through which technological problems are solved and how do they differ (i.e., troubleshooting, research and development, experimentation, invention and innovation, design problem solving)?
b. To what extent can design problems be approached through a series of generic procedures (the design loop)?
c. What design criteria is typically considered when developing new technologies (i.e., marketability, safety, useability, reliability, cost, materials, etc.) and how do these influence the final product/system design?
d. How are decisions made regarding information that should be discarded or ignored.
e. How can the attributes of design and the principles of design aid in the development of quality solutions?
f. How can the establishment of relationships, controlling variables, categorizing techniques, and making inferences aid in the development of new technological designs?

proBase Engaging Technology

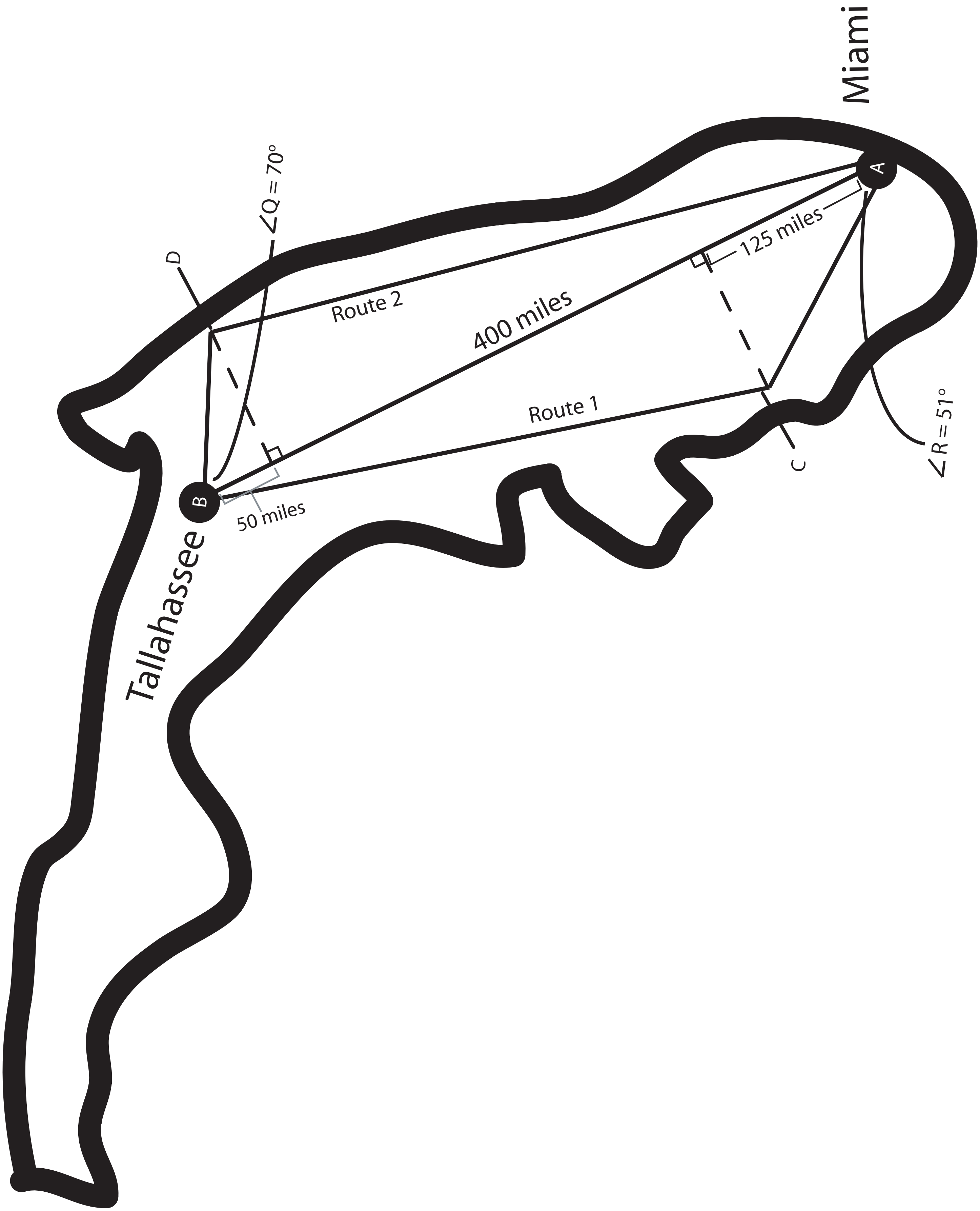
Teamwork Rubric

Observation of:	Criteria				Total Points
	4	3	2	1	
Helping - students offer assistance to one another	Consistently	Most of the time	Some of the time	None	
Listening - students work each others' ideas	Consistently	Most of the time	Some of the time	None	
Participating - students contribute to project/activity	Consistently	Most of the time	Some of the time	None	
Persuading - students exchange, defend, and rethink ideas	Consistently	Most of the time	Some of the time	None	
Questioning - students interact, discuss, and pose questions to all team members	Consistently	Most of the time	Some of the time	None	
Respecting - students encourage and support ideas and efforts of others	Consistently	Most of the time	Some of the time	None	
Sharing - students offer ideas and report their findings to each other	Consistently	Most of the time	Some of the time	None	
Collaborative - overall team work	Consistently	Most of the time	Some of the time	None	
				Total Points	

Additional comments:

General Discussion Rubric — Transportation Technologies

Element	Criteria				Total Points
	4	3	2	1	
Interpretation - Understanding of issues, concepts, questions, ideas, topics	- Explores implications of issue and goes beyond it - Accurately states and identifies issues - Expresses relevant knowledge base based on own thoughts	- Explains aspects of issues - Accurately states issues - Expresses relevant knowledge base based on own thoughts	- Understands issues - States relevant factual, ethical, or definitional issue as a question -Expresses relevant knowledge base based on another's idea	- Does not state issues - Does not express relevant base knowledge	
Evidence - Support of comments	- Uses strong evidence relevant to specific issue - Draws connections with other relevant items and prior knowledge - Thoroughly explains how it supports	- Uses strong evidence relevant to specific issue - Explains how it supports	- Uses weak evidence relevant to specific issue - Briefly explains how it supports	- Does not provide evidence relevant to specific issue	
Listening and Responding - Commenting on others' ideas	- Invites comments from others - Compares own ideas to others' - Agrees/disagrees with specific parts and explains reasons - Reassesses own stance	- Invites comments from others - Explains reasons for agreeing or disagreeing - Adds to or challenges others' ideas	- Summarizes others' ideas - Agrees or disagrees with other ideas	- Only listens to others speak, does not respond - Copies other ideas - Disruptive	
Participation - Contribution to discussion	- Participates willingly - Takes a leadership role - Asks specific questions	- Participates willingly - Asks questions	- Participates only when called on	- Does not participate in class discussion	
				Total Points	



Miami
A
∠Q = 70°
D
125 miles
Route 2
400 miles
Route 1
C
∠R = 51°
B
50 miles
Tallahassee

Design Challenge - Crash Test

Name: ______________

Mathematical Analysis Worksheet

1. Velocity:

   a. Length of guided course: ______________ meters
   b. Time to complete the course: ______________ seconds
   c. Velocity = Length/Time: ______________ m/s

2. Acceleration of your vehicle:
   Use the equation $A=2x/t^2$ where s = distance traveled, and t = time.

a. Acceleration of your vehicle: ______________ m/s^2

3. Force of your vehicle:
   Force = Mass x Acceleration

   a. Mass of your car: ______________ kg
   b. Acceleration: ______________ m/s^2
   c. Force = Mass x Acceleration: ______________ $kg\text{-}m/s^2$ (N)

4. Impulse Force of Impact (without a crumple zone):
   (If photo gate sensors are not available to measure the force of impact, use .01 sec for the time of deceleration for the following equations.)

   Force = (Mass x Change in Velocity)/Change in Time

   a. Mass of your car: ______________ kg
   b. O m/sec – Velocity (found in 1c): ______________ m/sec
   c. Reading from photo gate (or .01 s): ______________ s
   d. Impulse force of impact: ______________ Newtons

5. Impulse Force of Impact (with a crumple zone):
   (If photo gate sensors are not available to measure the force of impact, use .10 sec for the time of deceleration for the following equations.)

   a. Mass of your car: ______________ kg
   b. O m/sec – Velocity (found in 1c): ______________ m/sec
   c. Reading from photo gate (or .1 s): ______________ s
   d. Impulse force of impact: ______________ Newtons

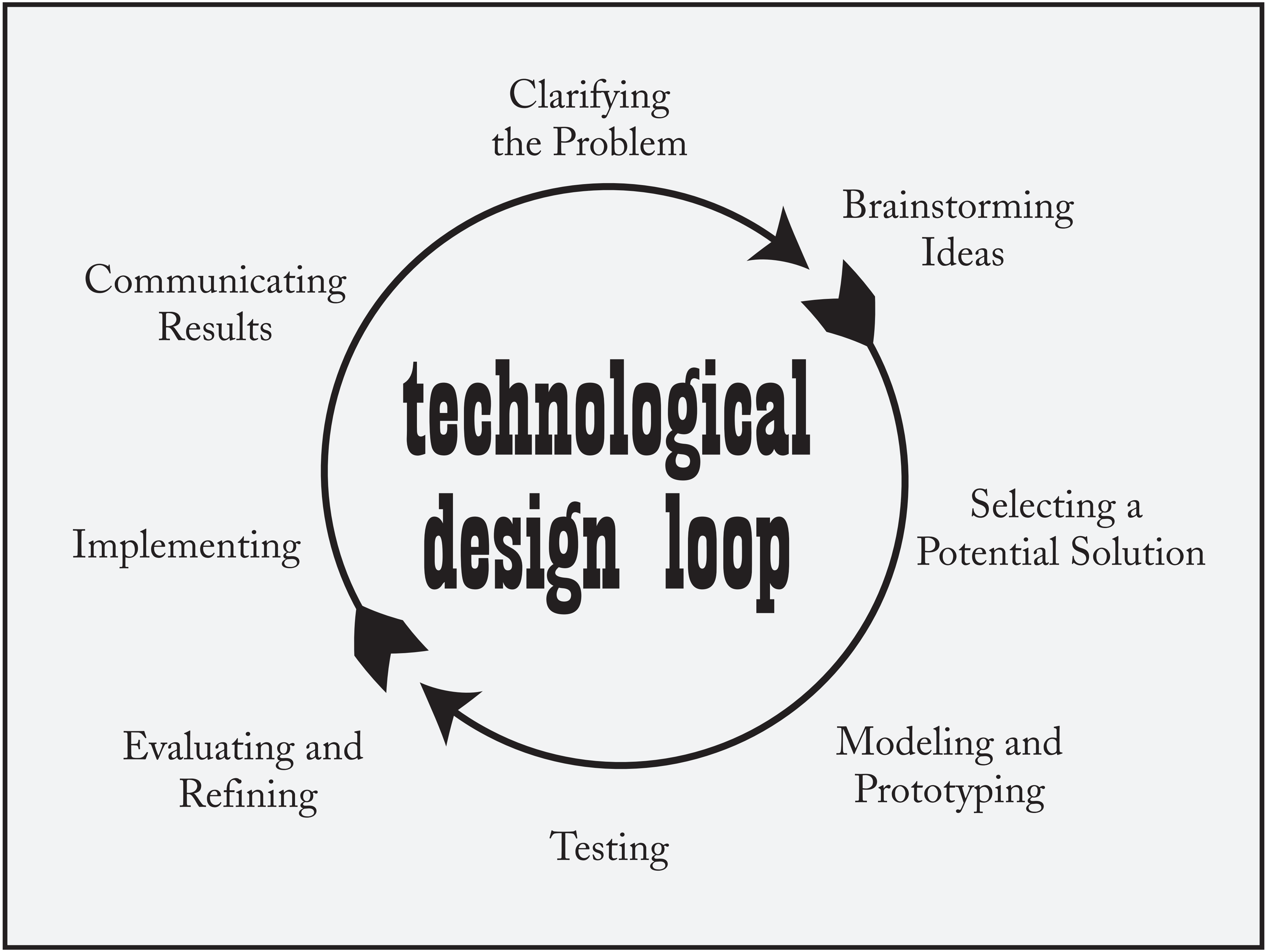
6. What is the difference in the impulse force at impact with a crumple zone?

   ______________ Newtons

TITLE:		SCALE:
DRAWN BY:	DATE:	ASSIGN:

TITLE: SCALE:

DRAWN BY: DATE: ASSIGN:


technological
design loop
Clarifying the Problem
Brainstorming Ideas
Selecting a Potential Solution
Modeling and Prototyping
Testing
Evaluating and Refining
Implementing
Communicating Results

In addition to ***Transportation Technologies,*** the ProBase curriculum series offers seven other Learning Units. The eight ProBase units can be used independently, in conjunction, or as an entire curriculum package. A brief description of each of the ProBase learning units follows. For more information contact the Center for Advancing the Teaching of Technology and Science.

Energy and Power Technologies

This unit examines how energy and power systems can be made more efficient and how they may be utilized in problem solving. The unit also focuses on how modern energy and power systems impact cultures, societies, and the environment.

Medical Technologies

This unit provides an analysis of how medical technologies are used to increase the quality and length of human life, and how increased use of technology carries potential consequences, which require public debate. The tools and devices used to repair and replace organs, prevent disease, and rehabilitate the human body are also explored.

Agriculture and Related Biotechnologies

This unit provides an analysis of the various uses and ethical considerations of biotechnology. The unit also examines how agricultural technologies provide increased crop yields and allow adaptation to changing and harsh environments, enabling the growth of plants and animals for various uses.

Information and Communication Technologies

This unit examines how technology facilitates the gathering, manipulation, storage, and transmission of data and how this data can be used to create useful products. The unit also explores how communications systems can solve technological problems.

Construction Technologies

This unit explores the factors influencing the design and construction of various structures, including the infrastructural elements, community development factors, and environmental considerations. In addition, the unit provides experience with hands-on construction techniques and with modeling structures to scale.

Manufacturing Technologies

The unit explores the process of changing raw materials into finished products and how manufacturing affects the standard of living of various peoples. In addition, issues such as the maintenance of manufacturing efficiency, the effects of human consumption on manufacturing, and manufacturing's effects on the standard of living of various peoples are examined.

Entertainment and Recreation Technologies

This unit explores technological entertainment and recreation systems and how their use impacts human leisure-time performance. The social, cultural, and environmental implications of entertainment and recreation technologies are also examined.

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